524

I.L.S. PRECISION CALIBRATOR

N100A MKII

INSTRUCTION MANUAL

WAYNE KERR

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CALIBRATION PROCEDURE FOR WAYNE KERR N100 Mk.II PRECISION I.L.S. CALIBRATOR

EQUIPMENT

Q.B. 33, Q.B. 34, PLESSEY TWO TONE GENERATOR, ADRET 740A SIGNAL GENERATOR

SWITCH ON ALL EQUIPMENT AND LEAVE FOR AT LEAST AN HOUR.

1) On the Two Tone Generator adjust the Tone Balance control to Zero the meter.

2) Set the Tone/Ratio control to 50% approximateley.

3) Connect the output of the Two Tone Generator to the Adret 740A External Modulation Input.

4) On Adret 740A select A.M. Modulation and set 37.5%/75% Modulation.

5) On the Two Tone Generator adjust the output control to calibrate the 740A External Mod.

6) On 740A select 110 Mhz/332 Mhz @ -27dBm/-17dBM.

7) Connect output of 740A to the head of the relevant Q.B.

8) On Q.B. 33/34 check both sets of batteries and charge if required.

9) Select Gain: adjust gain control to zero meter.

10) Select DDM: adjust Tone/Ratio control on Two Tone Generator to zero Q.B. meter.

11) Select Mod Sum: set Multiturn pot to MOD SUM result on the most recent C.A.A. calibration certificate.

12) Adjust 740A A.M. modulation level to zero Q.B. meter.

13) Transfer output of 740A to N100 LOC/GP input.

14) On N100 select Phase: adjust control to zero centre meter.
15) Select Set Null: adjust Set Null cotrol to zero right hand meter.

16) Select Mod Depth: hold down 'Calibrate' switch, adjust R.F. control to zero centre meter.

17) Releaae 'Calibrate' switch, set Mod Depth control to 20/40.

18) Adjust RV 1/RV 8 to zero centre meter.

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INSTRUCTION MANUAL

The reference number of this publication is TP23/3

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*circuit diagram.

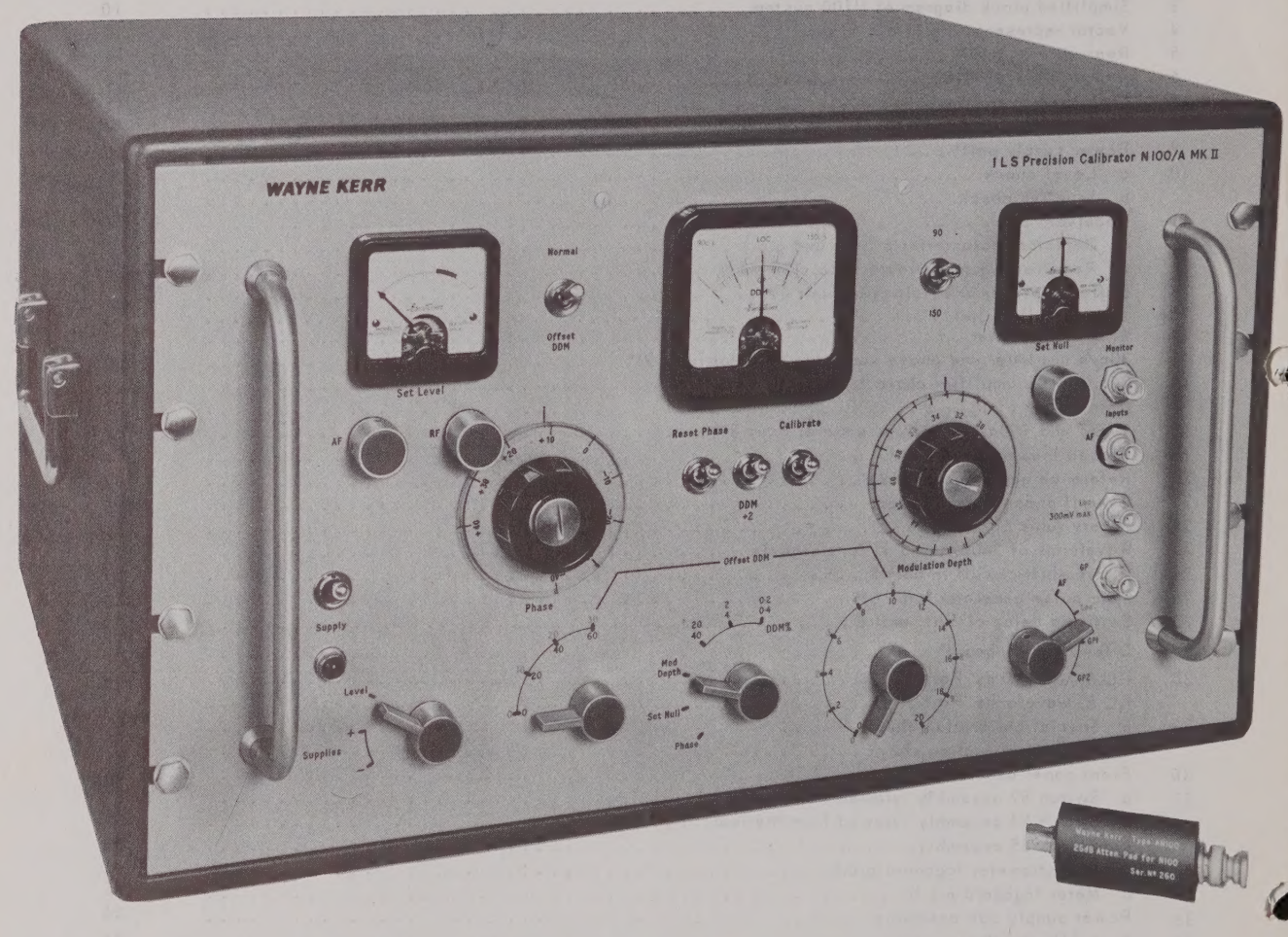


FIG.1 I.L.S. PRECISION CALIBRATOR N 100A Mk II

INTRODUCTION

The basic components of the I.L.S. system are two pairs of radio beams called localiser and glide path. Each pair of radio beams is generated by modulating a common carrier by two signals, one at 90c/s the other at 150c/s, and feeding the modulated carrier signals to separate aerials positioned with respect to a common reflector to produce two overlapping beams. The localiser guides the aircraft in azimuth and the glide path determines the angle of elevation on approach to the runway.

The N100 instrument incorporates a receiver, reference signal generator and a measurement channel and is designed to accept the I.L.S. localiser and glide path signals in either the a.f. or the r.f. form. The localiser and glide path transmitters and receivers are similar but operate at different carrier frequencies.

The two received tones of the localiser beam are of identical amplitude if the aircraft is over the centre line of the runway and the centre meter on the instrument panel then reads zero. Meter readings to left or right of the centre zero indicate a difference in depth of modulation of the common carrier by each of the two tones caused by deviation of the aircraft to the right or left, respectively, of the runway centre line. Deviation from the correct angle of descent is indicated in a similar manner using the glide path signal.

The meter does not indicate the difference in field strength of the two overlapping lobes of the I.L.S. aerial radiation pattern because a high degree of a.g.c. is incorporated in the receiver which prevents it responding to changes in level of the combined carrier. It is the difference in depth of modulation of the I.L.S. combined carrier by each of the two tones that the N100 compares and the meter is calibrated in percentage d.d.m.

Thus the N100 provides a method of measuring the parameter, difference in depth of modulation (d.d.m.), on which the I.L.S. system is fundamentally based. It will indicate zero d.d.m. within ±0.01 per cent on a.f. signals and within ±0.02 per cent on r.f. signals. A d.d.m. of 0.01 per cent corresponds to a displacement of azimuth of 2.7 in. at the threshold of the runway.

SPECIFICATION

Power requirements:
100/110V, 115/125V, 200/220V or 230/250V, 50 to 60c/s a.c. supply.
Consumption approximately 8 watts.

or

Two batteries, each 11.8 to 20V connected in series, with leads from positive, negative and common terminals.
Current consumption is approximately 160mA on each side. 12V accumulators may be used, or several hours of life can be obtained from four Ever Ready PP9 batteries. The PP9 batteries can be accommodated in the compartment at the rear of the instrument.

Input Signal:

	Localiser	Glide Path
R.F. (using Attenuator AN100)	50μV to 100mV r.m.s. at 108 to 112Mc/s	100μV to 100mV r.m.s. at 328 to 336Mc/s
A.F.	1V to 10V r.m.s.	1V to 10V r.m.s.
Relative phase of tones	Any	Any
Tone frequencies	90 and 150c/s ±1%, phase locked	90 and 150c/s ±1%, phase locked
R.F. modulation depth	Each tone 15 to 25% at zero d.d.m.	Each tone 30 to 50% at zero d.d.m.
D.D.M.	Up to 35%	Up to 70%

Offset Range	35% in 1% increments	70% in 2% increments

Accuracy of measurement:

		Localiser	Glide Path
D.D.M.	Zero Error	±0.01% on a.f. signals	
		±0.02% on r.f. signals	±0.04% on r.f. signals
	Scale Error	±3% f.s.d. on all scales	±3% f.s.d. on all scales
		Scales provided are 0.2%, 2%, 20% f.s.d. see Note 1, p.7.	Scales provided are 0.4%, 4%, 40% f.s.d. see Note 1, p.7.
Offset Error		±3% of setting	±3% of setting
Relative phase of tones		±5° at 90c/s for tone frequencies within 1.0%	±5° at 90c/s for tone frequencies within 1.0%
		±2° at 90c/s for tone frequencies within 0.25%	±2° at 90c/s for tone frequencies within 0.25%
Modulation depth		±0.5% relative to 100% *	±1% relative to 100% †

* For example, a dial indication of 20 means a modulation depth between the limits 19.5 and 20.5%.

† For example, a dial indication of 35 means a g.p. modulation depth between the limits 34 and 36%.

Recorder outputs: See note 4, p. 8.

Monitor point	Output
Monitor D.D.M. (jack)	±100μA f.s.d. Maximum external impedance 50 ohms 50 ohms external impedance gives a reduction in sensitivity of approximately 6% which can be corrected by using the Calibrate switch in conjunction with the level control, see instruction 11, p.9.
Monitor D.D.M. (sockets)	±100mV f.s.d. Minimum external impedance 3000 ohms
Monitor D.D.M. (sockets, with internal meter disconnected)	To disconnect internal meter insert dummy plug into the Monitor D.D.M. jack socket. ±100mV ±2% f.s.d. or ±500mV (approximately) for 5 times scale indication (i.e. 1% d.d.m. on 0.2% d.d.m. range) Minimum external impedance 1000 ohms
Monitor Null (jack)	±200μA f.s.d. Maximum external impedance 100 ohms
Monitor Null (sockets)	±50mV (approximately) f.s.d. Minimum external impedance 1000 ohms
Level (jack)	250μA f.s.d. Maximum external impedance 30 ohms

Dimensions: Width 20in. (51 cm.).
Height 11½in. (29 cm.)
Depth 14in. (37 cm.)

Weight: 55 lb. (25 kg.)

Note 1 The instrument is calibrated according to a normalised definition of d.d.m. generally accepted for localiser and glide path use, i.e.

d.d.m. = $[(E_{90} - E_{150})/5]$ x 100% for localiser

d.d.m. = $[(E_{90} - E_{150})/2.5]$ x 100% for glide path

which assumes that:

Modulation depth = $[(E_{90} + E_{150})/2E_C]$ x 100% is correctly set at 20 per cent or 40 per cent respectively.

where:

E_{90} is 90c/s signal amplitude

E_{150} is 150c/s signal amplitude

E_C is carrier signal amplitude

Thus the N100 used in conjunction with any I.L.S. installation will give an indication of *distance or angular displacement from the centre line of the runway which is independent of the modulation depth of the particular system.*

Note 2 A standard aircraft receiver gives indications which *vary in direct proportion to modulation depth.* For this type of indication a simple scaling factor may be used, i.e.

$$\text{scaled d.d.m.} = [\text{normalised d.d.m.}] \times \left[\frac{\text{actual modulation depth}}{\text{standard modulation depth}}\right]$$

where the standard modulation depth is 20% for localiser and 40% for glide path. To convert this reading to microamps the result should be multiplied by 9.7 for localiser and 8.6 for glide path.
For example, if

normalised d.d.m. = 2%
modulation depth = 18%
scaled d.d.m. = (18/20) x 2 = 1.8%
receiver indication = 1.8 x 9.7 = 17.5μA

Note 3 In the ICAO recommendations for receiver testing, the tones are increased and decreased by equal logarithmic increments from the mean e.g. 90c/s + 2db, 150c/s – 2db, and the mean modulation depth (A+B)/2 increases as the offset is increased. However, to obtain reading of true d.d.m. (i.e. receiver indication) under these conditions the N100 is set up at zero d.d.m. only and then the offset d.d.m. read off without readjustment of the set level control.

Note 4 All outputs except Level are unsmoothed, full wave rectified 30c/s, i.e. contain 60c/s and higher harmonics. Appropriate smoothing should be added when the output is fed to a rapid response recorder.

OPERATING INSTRUCTIONS

1 Switch on as follows:

Internal battery or a.c. supply	External battery
(1) Lift rear flap and check that the voltage selector is in the correct position (a.c. supply).	(1) Lift rear flap
(2) Switch the INT/EXT switch on the stabiliser unit to INT (a.c. or internal battery supply).	(2) Switch the INT/EXT switch on the stabiliser unit to EXT
(3) Connect supply plug (a.c. supply).	(3) Connect specified batteries to Ext Batt. terminals.
(4) Depress the Supply switch S1.	(4) Depress the Supply switch S1

2 Operate the Supplies switch to check the positive and negative supplies on the left hand meter.

R.F. Source

Note: An attenuator pad is clipped to the handle of each instrument. This pad is for use at r.f. levels above 10 mV and should be included at the appropriate input socket. Too high an r.f. input level may give incorrect modulation depth readings.

Setting up

3 Set the Input switch to the appropriate position i.e.
Loc for localiser input frequencies of 108Mc/s to 112Mc/s
GP1 for glide path frequencies of 328Mc/s to 332Mc/s
GP2 for glide path frequencies of 332Mc/s to 336Mc/s.
4 Set NORMAL/OFFSET DDM switch to NORMAL.
5 Connect the r.f. source or aerial to the appropriate r.f. input socket (Loc or GP) on the front panel.
6 Adjust the r.f. level as follows:
(a) Set the Function switch to Phase
(b) Set the Check switch to Level
(c) Use the R.F. Set Level control to set the left hand meter on the calibration mark.

Note: The instrument will function correctly provided that the indication is within the red band, but d.d.m. calibration will only be correct when the instrument is calibrated as operating instruction 10, see Note 1, p. 9

30c/s and 120c/s reference phase correction

7 With the Reset Phase switch in the up position (and the Function switch still set to Phase) rotate the Phase control to give zero reading on the centre meter. If zero reading cannot be obtained, depress the Reset Phase switch and rotate the Phase control to give zero reading on the centre meter. The relative phase of the two tones is read from the scale of the Phase control in terms of degrees at 90 cycles per second. Zero phase is the preferred relationship. See Note 2, p. 9
8 Turn the Function switch to Set Null and rotate the Set Null control to give zero reading on the right hand meter.
9 Repeat instructions 7 and 8.

Measurement of modulation depth

10 Set the Function switch to Modulation Depth and rotate the Modulation Depth control to give zero reading on the centre meter.
Read the modulation depth from the scale engraved on the Modulation Depth control. The reading given is $[(E_{90} + E_{150})/2E_C] \times 100$, see Notes 1 and 2, p.7.

Measurement of d.d.m.

11 Depress the Calibrate switch and adjust the Set Level control to give zero reading on the centre meter. (Function switch remains at Modulation Depth).
Note: This is the normal method of checking the calibration of the d.d.m. meter. The calibration may also be checked by turning the Function switch to 0.2% D.D.M., depressing the Calibrate switch and, if necessary, correcting the change of reading of the centre meter to exactly −0.2%, using the Set Level control. See Appendix 6, p.51.
12 Turn the Function switch to the appropriate d.d.m. setting and read on the centre meter.

The right hand meter should read zero, when the d.d.m. measurement is made. If the reading has altered it should be corrected to zero using the Set Null control.
13 If the offset facility is required for an accurate measurement well off zero D.D.M., adjust controls as follows:
Check the instrument is calibrated correctly as in operating instruction 11, see Note 1, below. Set Function switch to 20% D.D.M. and set NORMAL/OFFSET D.D.M. switch to OFFSET D.D.M. If the signal has a predominance of 90 c/s, set the 90/150 switch to 90 and for a predominant 150 c/s signal, set to the 150 position.
Adjust the OFFSET D.D.M. controls for a minimum on the centre meter. The amount by which the signal is offset from zero D.D.M. is obtained by the addition of the reading on the meter and the percentage indicated by the OFFSET D.D.M. Controls, observing relative polarities. If greater discrimination for the reading remaining on the meter is required, switch firstly to the 2% D.D.M. position and finally if possible, to the 0.2% D.D.M. position. Reset NORMAL/OFFSET D.D.M. switch to NORMAL.

A.F. Source

Setting up

14 Set the Input switch to A.F. & the NORMAL/OFFSET D.D.M. switch to NORMAL.
15 Connect the a.f. source to the A.F. Input socket on the front panel.
16 Adjust the a.f. level as follows:
(a) Set the Function switch to Phase
(b) Set the Check switch to Level
(c) Use the A.F. Set Level control to obtain a reading on the left hand meter exactly on the calibration mark.

30c/s and 120c/s reference phase correction

17 Follow instructions 7 to 9.

Measurement of d.d.m.

18 As instructions 11 and 12

Note 1: Correct d.d.m. calibration depends on accurate setting of the input signal level. The mean value of the incoming waveform is registered by the left hand meter, which will read high at large values of d.d.m. or in the presence of noise. Thus the left hand Level meter reading should be treated as a guide to give an approximate setting and the calibration method given in instruction 11 should be used to give the exact setting of the Set Level control.

Note 2: Phase calibration: Although the Phase control is calibrated in +40° and −40°, the maximum phase error is distinguished when 90c/s and 150c/s waveforms pass through zero in opposite directions at the same point and is 36° (this is antiphase to the preferred phase relationship). If the 90c/s phase is moved beyond this point, the waveform starts to return to the preferred relationship, and the phase control will indicate a reducing phase of opposite sign.
The calibration is affected by tone frequency.
See also Notes 1 and 2 of p.7.

PRINCIPLE OF OPERATION
(figs. 2, 3 and 4)

The principle of operation of the localiser and glide path channels of the N100 instrument are substantially the same. This description will therefore be confined to the localiser.

The modulated signals from the I.L.S., shown in fig. 2, are fed to the receiver of the N100, see fig. 3, which provides an a.f. signal comprising the 90c/s and 150c/s tones. With an r.f. input, a d.c. signal proportional to the carrier amplitude is also present. The d.c. and a.f. signals are separated in the buffer amplifier unit.

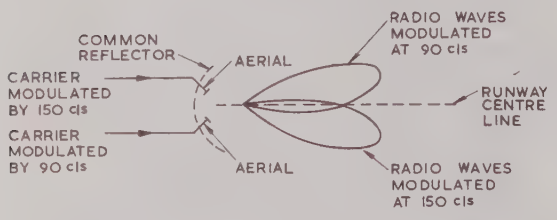
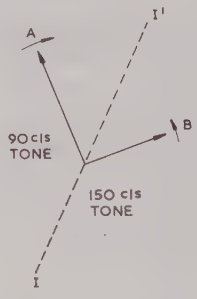


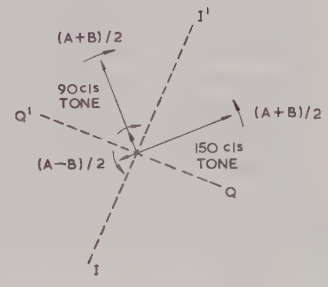
FIG. 2 ARRANGEMENT OF I.L.S. LOCALISER.

Appendix 1 shows that the composite signal comprising the 90c/s and 150c/s tones of unequal amplitudes A and B respectively can be represented by two vectors of equal length (A+B)/2 rotating in opposition about an axis II', together with two small vectors each of amplitude (A–B)/2 rotating in opposition about an axis of symmetry QQ', which is normal to the axis II', see fig. 4b. The axis II' is taken as the phase reference for the two tones. The composite signal may be regarded as the sum of two suppressed carrier systems of modulation. In each case, the suppressed carrier has a frequency of 120c/s, i.e. (150 + 90)/2, and the modulating signal a frequency of 30c/s, i.e. (150–90)/2. However, in one system the amplitude of modulation is A+B, whilst in the other system it equals A–B. Both the carriers and modulation signals are in phase quadrature.



4a.

TONE VECTORS RELATIVE TO 120 c/s REFERENCE AXIS



4b.

SYMMETRICAL SUM AND DIFFERENCE VECTORS EQUIVALENT TO 4a

POSITION OF AXIS II' CORRESPONDS TO THAT OF A VECTOR OF FREQUENCY = $\frac{150 + 90}{2}$ c/s = 120 c/s

FIG. 4. VECTOR REPRESENTATION OF A.F. SIGNAL.

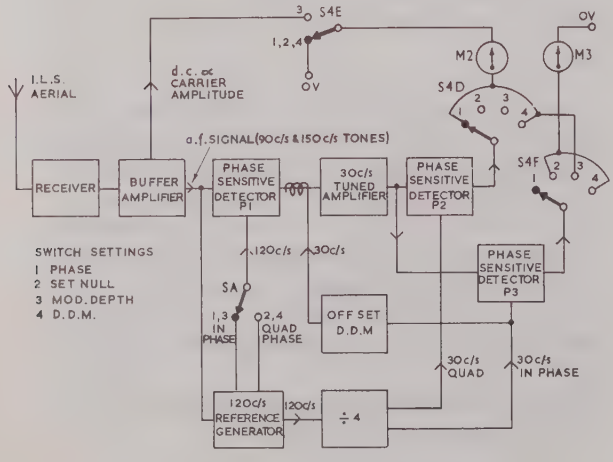


FIG. 3 SIMPLIFIED BLOCK DIAGRAM OF N100A SYSTEM

To measure small values of d.d.m. it is necessary to measure the difference in amplitude of the two tones after detection and express this difference as a percentage of the v.h.f. carrier amplitude. Determination of modulation depth requires measurement of the sum of the amplitudes of the two tones and comparison of this amplitude with that of the v.h.f. carrier.

The composite signal comprising the two tones is applied to the phase sensitive detector P1 and the 120c/s reference generator. The reference generator produces two 120c/s signals in phase quadrature and a 120c/s signal which is fed to the ÷4 unit; this unit produces 30c/s reference signals in phase quadrature. The reference signals available are therefore:

(1) In phase 120c/s and 30c/s reference signals having vectors coincident with axis II', fig. 4b.
(2) Quadrature 120c/s and 30c/s reference signals having vectors coincident with axis QQ', fig. 4b.

A true quadrature 120c/s reference has a vector coincident with axis QQ' and no component along axis II'. It will detect a 30c/s amplitude variation

along axis QQ'. A quadrature 120c/s reference having a phase error ϕ has a vector at an angle ϕ to axis QQ'. It will detect 30c/s components along axes QQ' and II'. Similarly, an in phase 120c/s reference having a phase error ϕ will detect 30c/s components along axes II' and QQ'. Thus P1, operating on the 120c/s reference, can detect the following signals:

(1) A 30c/s component along axis QQ': A true quadrature 120c/s reference applied to P1 will result in detection of a 30c/s amplitude variation along axis QQ' which is proportional to the difference in amplitude of the two tones (A–B).

(2) A 30c/s component along axis II': A true in phase 120c/s reference applied to P1 will result in detection of a 30c/s amplitude variation along axis II' which is proportional to the sum of the amplitudes of the two tones (A+B).

(3) Two 30c/s components in phase quadrature: If the quadrature 120c/s reference has a phase error, P1 will detect a 30c/s component along axis II' in addition to the signal described in (1) above. Similarly, if the in phase 120c/s reference has a phase error, P1 will detect a 30c/s component along axis QQ' in addition to the signal described in (2) above.
See Appendix 2.

The two components in phase quadrature can be separated by using a further pair of phase sensitive detectors P2 and P3, which operate on the quadrature and in phase 30c/s references, respectively, so that one detects the quadrature component relating to QQ' and the other the in phase component relating to II'. The 30c/s signal from P1 is amplified and applied to P2 and P3, which provide indications of any phase error in the 120c/s and 30c/s reference signals and measurement of modulation depth and d.d.m. as follows:

(1) Phase error θ in the common source of the 30c/s reference: A phase error in the common source of the 30c/s is indicated on meter M2 when an in phase 120c/s reference, which may have a small phase error ϕ, is applied to phase sensitive detector P1 (switch SA set to Phase). The output of P2, operating on the quadrature 30c/s reference having a phase error θ, is then approximately proportional to (A+B) sin θ.
Correction of the phase error of the common source of the 30c/s reference, so that θ becomes zero, is indicated by zero reading on meter M2, see Appendix 3, section 3.1.

(2) Phase error ϕ in the 120c/s reference signals: Phase error in the 120c/s reference signals is indicated on meter M3 when a quadrature 120c/s reference, having a phase error ϕ, is applied to phase sensitive detector P1 (switch SA at Set Null position). The output of P3, which operates on the in phase 30c/s reference, is then proportional to (A+B) sin ϕ. Correction of the phase error in the 120c/s reference, so that ϕ becomes zero, is indicated by zero reading on M3. See Appendix 3, section 3.2.

(3) Percentage modulation depth: Phase sensitive detector P3, which operates on the in phase 30c/s reference, gives an output proportional to (A+B) when the in phase 120c/s reference is applied to P1 (switch SA set to Modulation Depth). The signal from P3 is fed to meter M2 together with an opposing d.c. signal proportional to the carrier amplitude. The value of the d.c. signal is adjusted, by means of the Modulation Depth control, for zero meter reading; the control dial is calibrated in percentage depth of modulation. See Appendix 3, section 3.3.

(4) Percentage d.d.m.: The output of phase sensitive detector P2, which operates on the quadrature 30c/s reference, is proportional to (A–B) when P1 operates on the quadrature 120c/s reference (switch SA set to D.D.M.). Meter M2 registers the output of P2 and is calibrated to read d.d.m. per cent. See Appendix 3, section 3.4. P3 provides an indication on meter M3 as in section (2) above if there is an error in the phase of the 120c/s reference. Correction of this phase error is made by using the Set Null control to give zero meter indication as above.

Section 3.5 of Appendix 3 shows that it is advantageous to correct errors in the phase of the common source of the 30c/s reference signals before proceeding to correction of the phase of the 120c/s reference signals.

An offset facility can be switched into circuit providing a means of offsetting the incoming signal, permitting measurements to be made in the 0 to 0.2% D.D.M. % range. A 30 c/s square wave from the binary unit is fed through a low pass filter giving a 30 c/s sine wave output. This signal is connected to two calibrated attenuators in series, the attenuator outputs are summed together and mixed with the incoming signal by means of a transformer. The output connections of the mixing transformer can be reversed, using the 90/150 switch on the front panel, thereby selecting the polarity of the 30 c/s signal to offset a predominance of 90 c/s or 150 c/s present on the input signal.

GENERAL DESCRIPTION

The instrument comprises the following units:

1 A power supply unit. A compartment is provided for the insertion of batteries as an alternative supply. If external batteries are used they are connected to terminals provided at the rear of the instrument.

2 A stabiliser unit, which is supplied from the power supply unit or batteries, provides stabilised −11V and +11V d.c. lines for the instrument.

3 A receiver unit for r.f. signals from the I.L.S.

4 Buffer amplifier and multiplier *unit 1*, contains amplifying, multiplying and filtering circuits, and the phase sensitive detector P1.

5 30c/s amplifier and phase sensitive detector *unit 2*, which contains a 30c/s selective amplifier and the phase sensitive detectors P2 and P3.

6 90 c/s and 150 c/s filters, squarers and summing amplifier unit 3, which separates the two tones and produces an accurately squared 150 c/s signal and a 90 c/s sine wave.

7 A reference generator *unit 4*, which provides a 240c/s signal.

8 A binary *unit 5*. The unit is supplied by the 240c/s signal from unit 4; the five binary circuits in the unit produce two 120c/s references in phase quadrature and two 30c/s signals in phase quadrature.

9 Sync pulse generator *unit 6*, which produces the signal required for synchronising the binary circuits.

10 The 30 c/s Filter/Amplifier to provide signals for *Offset facilities* is mounted on *unit 6*.

The front panel of the instrument carries the components required for operating the instrument, see fig. 1. These are:

1 *Meters:* Three meters display the information. These are:

(a) Left hand meter M1 which indicates the audio signal level, i.e. a.f. or detected r.f., or registers the supply voltages as required.

(b) Centre meter M2, which shows a deflection from centre zero for any phase error in the common source of the 30c/s reference or indicates the percentage d.d.m. It is also used in the measurement of percentage modulation depth.

(c) Right hand meter M3 indicates any error in the phase of the 120c/s reference.

2 *Switches:* The following switches are provided:

(a) Supply switch (S1): Operation of the Supply switch either feeds the a.c. supply to the power unit in the instrument or the external or internal battery supply to appropriate terminals on the stabiliser unit. The output of the power supply unit is fed directly to the stabiliser unit. Supply lamp LP1 indicates the presence of stabilised supplies to the instrument. See fig. 7.

(b) Check switch (S2): The Check switch selects the audio signal or supply voltage for display on Meter M1.

(c) Calibrate switch (S3): The Calibrate switch is used for checking the d.d.m. calibration of meter M2, see Appendix 6, p.51.

(d) Function switch (S4): The Function switch selects conditions for correction of phase errors in the 30c/s or 120c/s references, measurement of percentage modulation depth or d.d.m. as required.

(e) Input switch (S5): The a.f. or r.f. signal (localiser or glide path) from the I.L.S. is selected by the Input switch.

(f) Reset Phase switch (S6): The time delay in the sync pulse generator unit 6 is selected by means of the Reset Phase switch.

(g) ÷2 switch (S7): The sensitivity of meter M2 is adjusted by depressing the ÷ 2 switch. Meter readings should be multiplied by two when the switch is operated.

(h) Normal/Offset (S1004): In the Offset position this switch brings in a simulated offset signal to back off the D.D.M. meter reading towards zero and enables a more precise measurement to be made.

(i) 90/150 (S1003): The offset phase is selected by this switch.

(j) & (k) Offset D.D.M. (S1001 & S1002): These switches determine the amount of offset produced and are calibrated in percentage D.D.M.

3 *Controls:* The following controls are provided:

(a) Set level (RV5, RV6): The Set Level controls adjust the level of the a.f. or r.f. signals from the I.L.S.

(b) Phase control (RV7): The phase control is operated to correct the phase of the common source of the 30c/s reference.

(c) Set Null control (RV4): The Set Null control adjusts the phase of the 120c/s reference.

(d) Modulation Depth control (RV2): The Modulation Depth control adjusts the d.c. signal (proportional to the carrier amplitude) which is fed to meter M2 in opposition to the d.c. (proportional to the sum of the amplitudes of the two tones) in the Mod Depth setting of the Function switch. The control is calibrated in percentage modulation depth.

4 *Input and Monitor sockets* (SKT2, SKT3, SKT15 and SKT1). The input sockets (SKT2, SKT3 and SKT15) are for the connections of audio frequency (AF), localiser (LOC) and glide path (GP) inputs from the I.L.S. respectively. The d.c. & a.f. voltage proportional to the amplitude of the combined carrier of the I.L.S. is checked at the Monitor socket (SKT1).

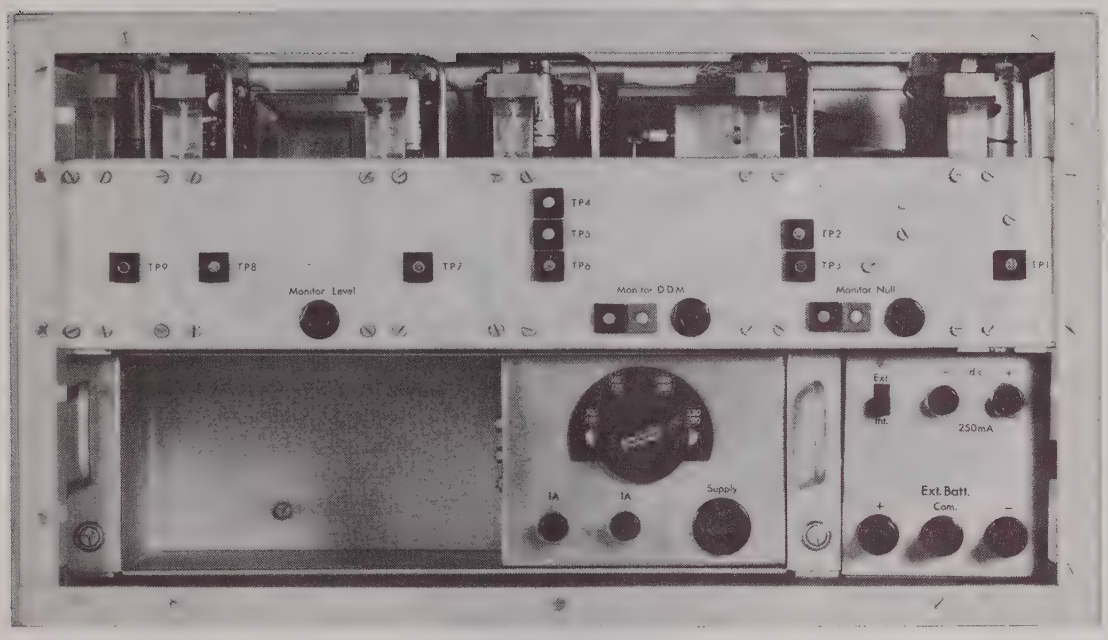


FIG.5 REAR VIEW OF N100

Lifting the flap at the rear of the instrument exposes the lower half of the rear of the instrument, see fig. 5. The compartment for the accommodation of internal batteries (left) and the panels of the power supply unit (centre) and stabiliser unit (right) are then visible. The following components are mounted on the two panels:

1 *Voltage selector switch:* The switch provides selection of the correct tapping on the primary of the supply transformer.
2 *A.C. supply fuses.*
3 *Three pin a.c. supply socket.*
4 *Ext/Int switch:* The internal power supply or batteries, or the external battery supply are connected to the stabiliser circuit through the Ext/Int switch contacts, see fig. 8.
5 *D.C. line fuses.*
6 *Ext Batt terminals:* The terminals are provided for connection of the external batteries.

When the eight fixing screws holding the instrument in its case are loosened and the chassis is withdrawn, the upper rear panel is seen. This panel carries the following test and monitor sockets: (see fig. 7 and system circuit diagram)

1 *TP1:* Test point for the 30c/s output from phase sensitive detector P1 in unit 1.
2 *TP2, TP3:* Test points for the quadrature and in phase 30c/s references from binary units B4 and B5.
3 *TP4, TP5, TP6:* Test points for the 90c/s and 150c/s sine waves and 150c/s square wave from unit 3.
4 *TP7:* Test point for the 240c/s output from the frequency controlled multivibrator in unit 4.
5 *TP8:* Test point for 120c/s signal to binary B3 in unit 5.
6 *TP9:* Test point for sync pulse from unit 6.
7 *Monitor Level:* Jack socket JK1 for monitoring the level of the input signal.
8 *Monitor D.D.M.:* Sockets SKT4, SKT5 and jack socket JK2 for monitoring the d.d.m. signal on external meter or recorder.
9 *Monitor Null:* Sockets SKT6, SKT7 and jack socket JK3 for monitoring the 120c/s phase error signal.

The six units are mounted on printed circuit boards which can be individually withdrawn for servicing, see fig. 6.

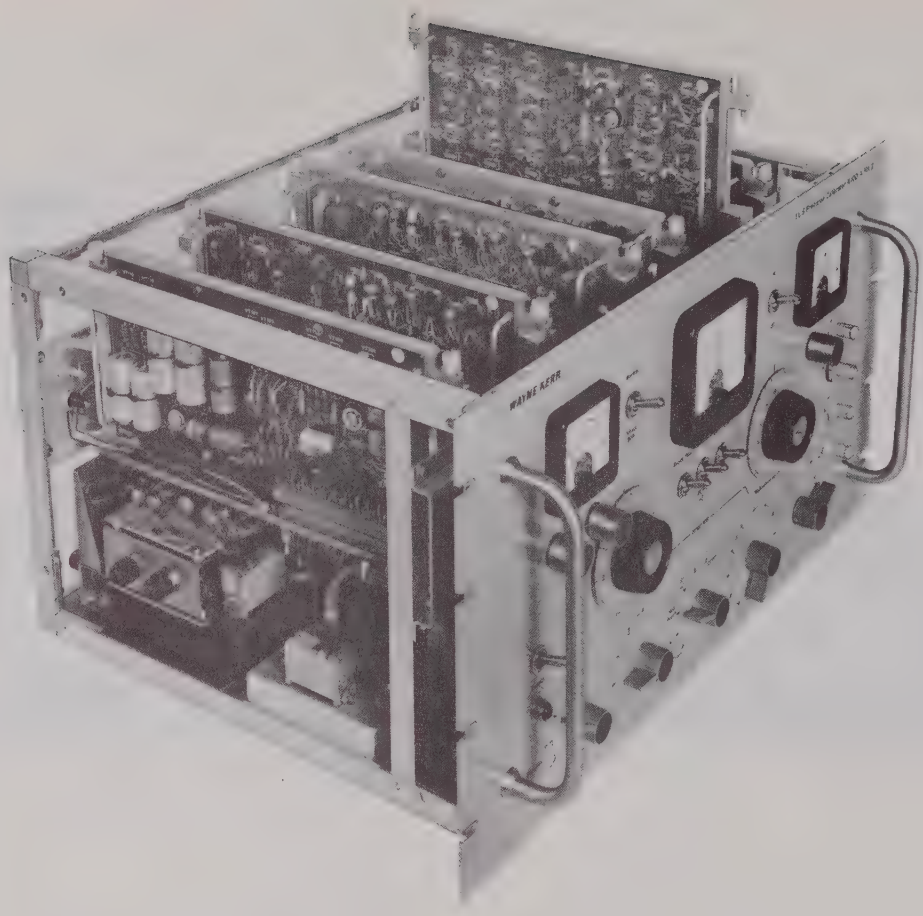


FIG. 6 INTERIOR VIEW OF N100

CIRCUIT DESCRIPTION

The circuit description is divided into two sections, the first of which deals with the general overall system and the other gives details of the individual circuits.

Overall System (fig. 7)

The I.L.S. modulated v.h.f. carrier is fed from the I.L.S. to the N100.

R.F. input

The localiser r.f. input signal passes through a receiver which has a 4Mc/s bandwidth centred at 110Mc/s, whilst the glide path r.f. signal receiver covers 4Mc/s centred at 330Mc/s and 4Mc/s centred at 334Mc/s. The wide bandwidth of the receivers enables all I.L.S. channels to be accepted without switching.

The precision detector for the r.f. signal has a characteristic which enables a modulation depth of 20 per cent to be measured to ±0.5 per cent and a modulation depth of 40 per cent to ±1 per cent.

A high degree of a.g.c. is incorporated in the receiver circuits to prevent response to changes of level of the combined carrier, because it is *difference in depth of modulation* (d.d.m.) of the combined carrier by each of the two tones that is to be measured. The a.g.c. is such that, using Attenuator AN100, signals from 100μV to 100mV r.m.s. can be received with less than 10 per cent change in the detected output. This change can be compensated by adjustment of the Set R.F. Level control RV6.

The output of the receiver is an a.f. signal comprising the 90c/s and 150c/s tones and a d.c. proportional to the detected carrier. This output is passed to the buffer amplifier unit 1 through the 50K Set Level R.F. control RV6 in the R.F. setting of the Input switch S5.

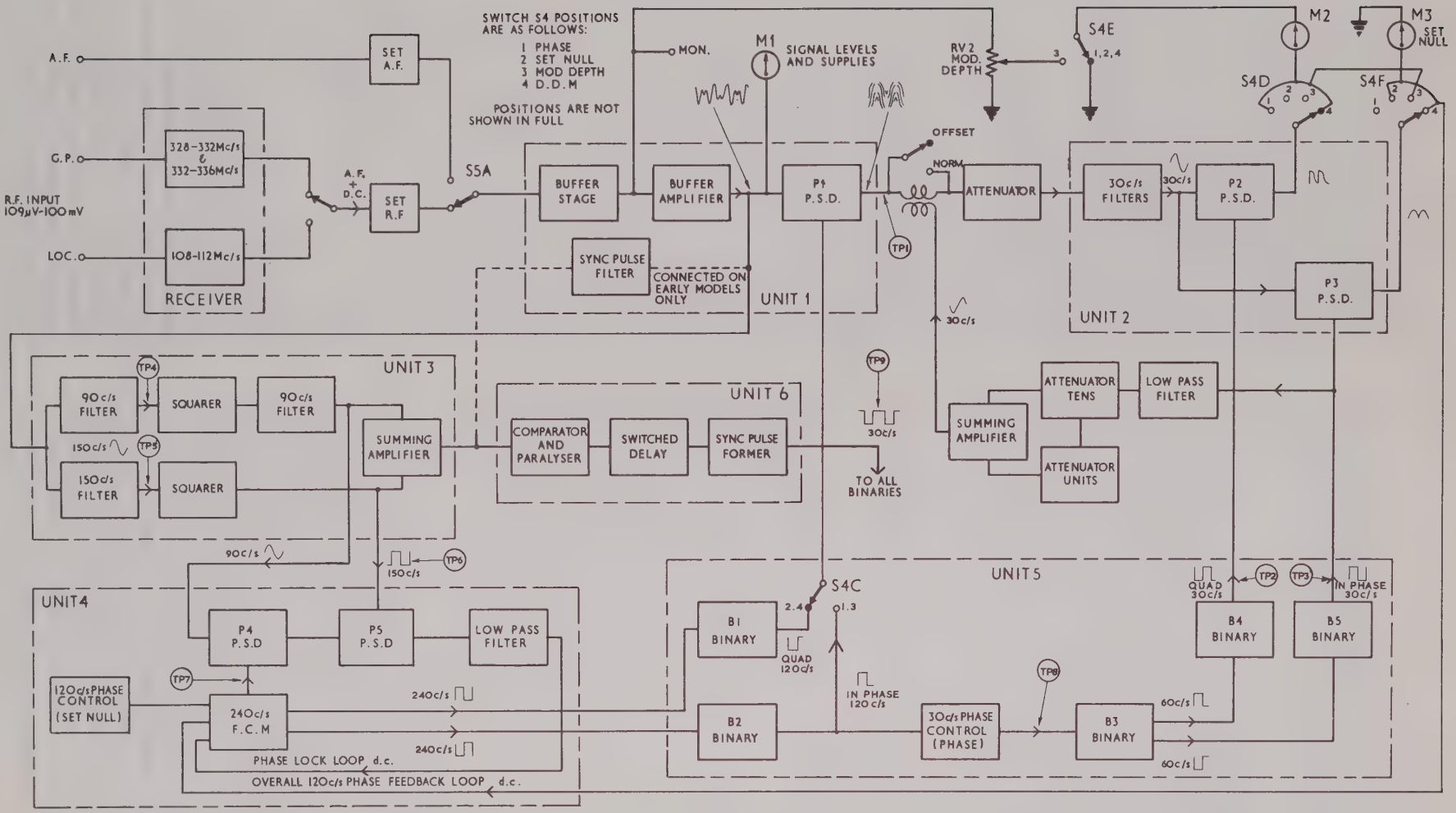


FIG.7 SIMPLIFIED OVERALL SYSTEM

A.F. input

The a.f. input from the I.L.S. is passed through the 250K Set A.F. Level Control RV5 which accepts signals from 1V to 10V r.m.s. The signal is fed to the buffer amplifier when the input switch S5 is set to A.F.

Buffer amplifier

The buffer stage of unit 1 presents a high input impedance to the incoming r.f. or a.f. signal from the I.L.S. or N100 receiver. The a.f. and d.c. component of r.f. input signals are separated, the d.c. signal being fed through the Modulation Depth control RV2 and section S4E of the Function switch to the centre meter M2 when the switch is turned to the Mod Depth setting. The I.L.S. tones are passed through the buffer stage to the buffer amplifier.

The nominal modulation depth of the localiser signal is 20 per cent whilst that of the glide path signal is nominally 40 per cent. The gain of the buffer amplifier is therefore exactly halved by additional internal feedback for glide path signals. The buffer amplifier provides a very low impedance output for all succeeding stages.

Control signals

The buffer amplifier output signal is fed to the 90c/s and 150c/s filter and squarer unit 3. The 90c/s and 150c/s signals are isolated from each other in the unit and a 90c/s sine wave and an accurately squared 150c/s output provided.

On early models an additional output from the buffer amplifier is fed to the sync pulse generator, unit 6, via a sync pulse filter. Unit 6 produces a synchronising pulse at 30 c/s from the incoming signal, which is used to synchronise the reference signals. On later models, unit 6 is driven by a combination of 90 c/s and 150 c/s derived after filtering in unit 3, providing a synchronising waveform which is insensitive to change of D.D.M.

Reference signal channel

The reference generator unit 4 comprises a 240c/s frequency controlled multivibrator (f.c.m.), which is locked to the incoming signal, two phase sensitive detectors P4 and P5 and a filter. The two phase sensitive detectors and filter form a phase lock loop which controls the f.c.m. through its control circuit operating in the following manner. The 90c/s sine wave from the filter and squarer unit 3 is switched in P4 by the 240c/s signal from the f.c.m. The output of P4 contains, among other high frequency components, a signal at 150c/s. The 150c/s signal from P4 is switched in P5 by the accurately squared 150c/s signal from unit 3. The output of P5 is passed through the low pass filter and the output from the filter, a d.c. signal, is passed to the control circuit which adjusts the phase of the f.c.m.

An overall 120c/s phase feedback loop is provided by applying a d.c. signal proportional to $(A+B) \sin \phi$ from the output of the measurement channel to the f.c.m. control circuit.

Fine manual 120c/s phase control (Set Null) is provided by a d.c. signal fed to the f.c.m. control circuit from the wiper of the Set Null control RV7. The control is connected across the stabilised +11V and –11V d.c. supply lines. The Set Null control is used to correct the phase of the multivibrator output through its control circuit so that any phase error in the 120c/s reference is reduced to zero.

Two 120c/s reference signals in phase quadrature are derived from the two antiphase 240c/s signals from the reference generator unit 4 by binary stages B1 and B2 in unit 5.

The in phase 120c/s signal from B2 (vector coincident with axis II', fig. 4) is passed through a 30c/s phase control circuit to binary B3. The phase control circuit is a normal variable delay circuit which operates on the switching edge of the 120c/s signal feeding B3. The required phase shift is ±45° at 120c/s to accommodate the complete cycle involved in change of the relative phase of the 90c/s and 150c/s tones.

Binary B3 produces two 60c/s signals in phase quadrature, which are applied to binary circuits B4 and B5. The quadrature 30c/s reference (vector coincident with axis QQ' of fig. 4) is derived by binary B4 and the in phase 30c/s reference (vector coincident with axis II' of fig. 4) is derived by binary B5. The phase shifting is performed on the switching edge of the 120c/s signal from which the 30c/s reference is derived in order to preserve the 1:1 mark space ratio of the 60c/s signal, which is essential for accurate derivation of the two 30c/s reference signals in phase quadrature.

The phasing of the signals in the reference chain will be indeterminate unless the binaries are all in a known state to start with and are also checked at regular intervals to ensure that the system is not upset by stray interfering pulses. This is achieved by applying the synchronising pulse direct from the incoming signal, provided by unit 6, to one side of each of the binaries in unit 5 thus ensuring that they are in the correct state at the time of the pulse.

Measurement channel

The amplified a.f. signal containing the 90c/s and 150c/s tones from the buffer amplifier in unit 1 is also applied to meter M1 for checking the a.f. level and to phase sensitive detector P1 in the unit. The signal is switched in P1 by the 120c/s reference from binary unit 5. If the Function switch is set to Phase or Mod Depth, the in phase 120c/s reference operates on P1. If the Function switch is set to Set Null or D.D.M. the quadrature 120c/s reference operates on P1. The output of P1 is filtered and the

following signals are passed through the offset D.D.M. mixing transformer and the switched attenuator to the next stage of the measurement channel:

1 A 30c/s signal with amplitude variation proportional to (A+B) along axis II' of fig.4. P1 is switched by the in phase 120c/s reference to obtain this output.
2 A 30c/s signal with amplitude variation proportional to (A−B) along axis QQ' of fig.4. P1 is switched by the quadrature 120c/s reference to obtain this output. The switched attenuator provides the appropriate sensitivity according to the position of the Function Switch. The 30 c/s offset signal from the offset D.D.M. circuit is mixed with this signal when the offset facility is selected.

The signal then passes through two 30c/s selective filters of the positive feedback Wien bridge type. The filters are of very high stability with respect to phase and gain over the required temperature range.

The signal from the 30c/s filters is switched in phase sensitive detectors P2 and P3 by the quadrature and in phase 30c/s reference signals respectively. The outputs of P2 and P3 are d.c. signals which are fed to meters M2 or M3 according to the setting of the Function switch. The indications on meter M2 are used for correction of the phase of the 30c/s reference, measurement of percentage modulation depth and d.d.m., whilst the indication on meter M3 is used for phase correction of the 120c/s reference. The following table summarises the outputs available from the measurement channel.

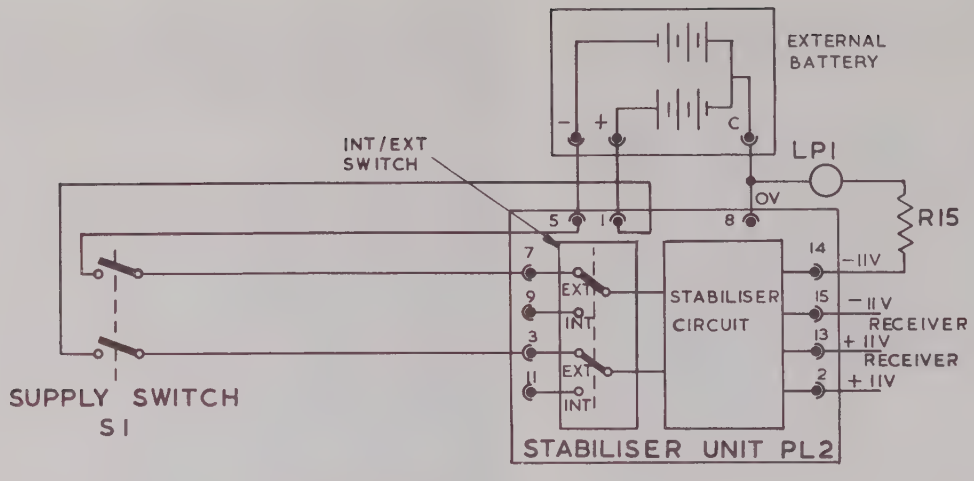
Switch S4 setting	Phase of reference signals to			Output of measurement channel
	P1(120c/s)	P2(30c/s)	P3(30c/s)	
Phase	In phase + error ϕ	Quadrature + small error θ		d.c. signal approximately proportional to (A+B) sin θ from P2 to meter M2 for phase correction of 30c/s reference.
Set Null	Quadrature + error ϕ		In phase	d.c. signal proportional to (A+B) sin ϕ from P3 to meter M3 for phase correction of 120c/s reference.
Mod Depth	In phase		In phase	d.c. signal proportional to A+B from P3 to meter M2. In addition, a d.c. signal proportional to the carrier amplitude is fed to M2 in opposition to the signal from the measurement channel. Percentage modulation depth is read on Modulation Depth control when meter reading is adjusted to zero.
D.D.M.	Quadrature	Quadrature		d.c. signal proportional to A−B from P2 to M2. The meter is calibrated in percentage d.d.m.

Individual Circuits

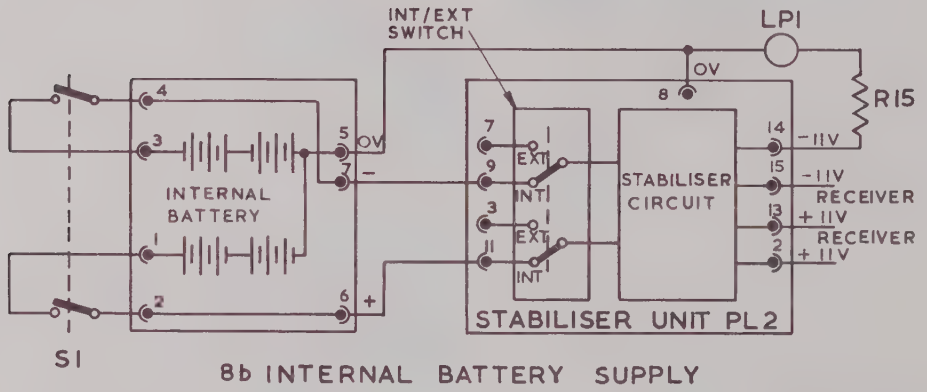
Power supply (figs. 8 and 9)

The N100 can be operated from batteries or a.c. supply as follows:

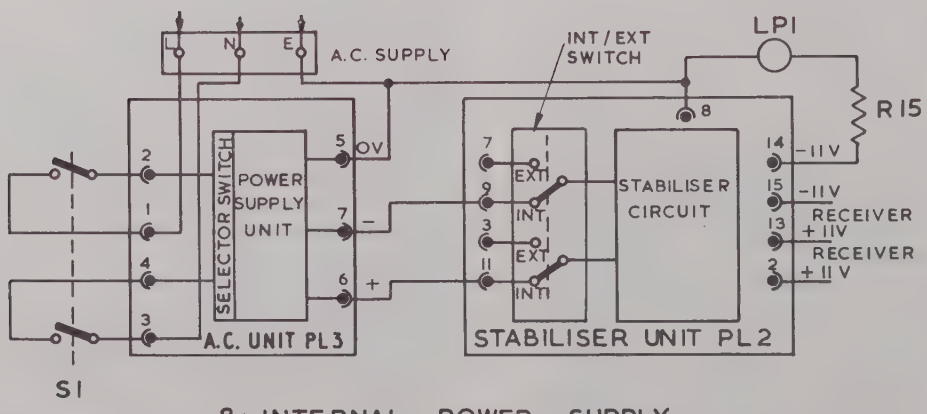
1 External batteries: The batteries are connected to the three external battery terminals provided on the panel of the stabiliser unit. These terminals are exposed by raising the rear flap of the instrument. The INT/EXT switch at the rear of the instrument is set to EXT, and the supply is connected to the stabilising circuit by depressing the Supply switch S1, see fig. 8a.
2 Internal batteries: A compartment is provided under the rear flap of the instrument for accommodation of the batteries, which are connected to terminals on the panel of the power supply unit. The INT/EXT switch is set to INT, and the supply is connected to the stabilising circuit by operating the Supply switch, see fig. 8b.
3 A.C. supply: The a.c. supply is plugged into the three pin socket provided on the panel of the power supply unit and connected through the selector switch contacts to the correct tapping on the primary winding of transformer T801. The centre tapped 14V r.m.s. output from the secondary winding of T801 is fed to bridge rectifier MR801 to provide positive and negative d.c. outputs at approximately 16V. C801 and C802 are reservoir capacitors and resistors R813 and R814 prevent any heavy switching surge currents. The d.c. output of the power supply is connected to the stabilising circuit by setting the INT/EXT switch to INT, see figs. 8c and 9.



8a EXTERNAL BATTERY SUPPLY



8b INTERNAL BATTERY SUPPLY



8c INTERNAL POWER SUPPLY.

FIG. 8. SIMPLIFIED BLOCK SCHEMATIC OF POWER SUPPLY.

Stabiliser unit

The stabiliser circuit is designed to operate from batteries or the power supply unit. The circuit must be capable of operating with a very small input because the battery potential may fall as low as 11.7V. Two stabilised d.c. supplies are available:

1 −11V d.c. supply: Transistors VT804, VT805 and VT806 and their associated components form the stabilising circuit for the −11V supply. The emitter of voltage amplifier VT804 is maintained at approximately −7.5V by voltage reference diode MR804 connected in series with silicon diode MR805, which provides temperature compensation. Current is supplied from the stabilised −11V line through resistor R805 to MR804 and MR805. The potential at the base of VT804 is taken from the wiper of preset control RV803 which is part of the potential divider chain connected across the stabilised −11V d.c. line. VT804 is supplied with collector current from the unstabilised line through resistor R802. The collector current of VT804 must not fall below 100 microamps even at low input voltages. The value of R802 is therefore chosen to compromise between obtaining a reasonable power gain in VT804 and maintaining this gain at low input voltages.
Differences between the reference potential at the emitter of VT804 and its base potential are amplified by the transistor and passed to the base of emitter follower VT805. The series regulator VT806 is driven by VT805 and controlled by VT804 to provide a stable −11V supply.
Stabilisation is improved by a feed forward circuit through resistor R803 and preset control RV801 to the base of VT804. RV801 is adjusted at production for minimum ripple in the −11V d.c. line at the normal supply voltage. The output impedance of the stabilising circuit at high frequency is reduced by capacitor C804.
Additional smoothing is necessary for the −11V stabilised supply for the receiver and this is provided by resistor R811 and capacitor C806.

2 +11V d.c. supply: The stabilising circuit for the +11V d.c. supply is similar in design to that for the −11V supply. The series regulator transistor is operated in common emitter configuration and forms a feedback pair with VT802. The controlling voltage amplifier VT803 is an npn transistor. There is also a +11V supply for the receiver which has additional smoothing provided by resistor R812 and capacitor C805.

The power supply voltages are checked on meter M1 by setting the Supplies switch to + or − as required. The measurement circuit is shown in the system diagram at the end of the manual and in the simplified diagram of fig. 10.

Receiver (figs.11, 12 and unit interconnection diagram)

The localiser input, i.f. and a.g.c. circuits of the receiver are on printed circuit board whilst the glide path input circuit is conventionally wired. The i.f. frequency is 33Mc/s.

Special care is taken in the otherwise conventional receiver design and a wide range of a.g.c. provided to ensure accurate measurement of d.d.m. and modulation depth. The supply to the a.g.c. system has additional smoothing to prevent distortion by re-modulation of the r.f. signal in the controlled stages, which would result in slight changes in d.d.m. The d.c. lines are well decoupled, especially at a.g.c. controlled stages, to prevent modulation by signals such as 150c/s supply ripple and 90c/s and 150c/s fed back from the a.f. units. Errors due to spurious modulation are less than 0.01 per cent d.d.m. Alteration of the modulation depth of the signal from the I.L.S. due to signal limiting in any stage is avoided. Interaction between the amplifier and the detector which drives it is prevented by the design of the a.g.c. amplifier and its smoothing.

The final i.f. detector gives sufficient power over the 4Mc/s bandwidth to avoid signal limitation at high modulation depths and has a very linear response characteristic over a wide voltage range.

Receiver power supply (system diagram)

The receiver −11V, +11V and 0V lines are directly connected from pins 15, 13 and 8 of the stabiliser unit plug PL2 to pins 2, 4 and 8 respectively of the receiver plug PL702. In the A.F. setting of S5 there is no supply to the localiser and glide path input circuits. In the other positions of S5, the localiser and glide path input circuits are supplied as follows:

1 Loc: −11V is taken to pin 15 of PL702 through switch section S5E and +11V to pin 13 of PL702 through switch section S5D.

2 GP1: −11V is taken to pin 7 of PL702 through switch section S5E and +11V to pin 5 of PL702 through switch section S5D. In addition, provision is made for adjustment of the frequency of the oscillator in the glide path input circuit by connecting pins 9 and 11 of PL702 together through switch section S5C.

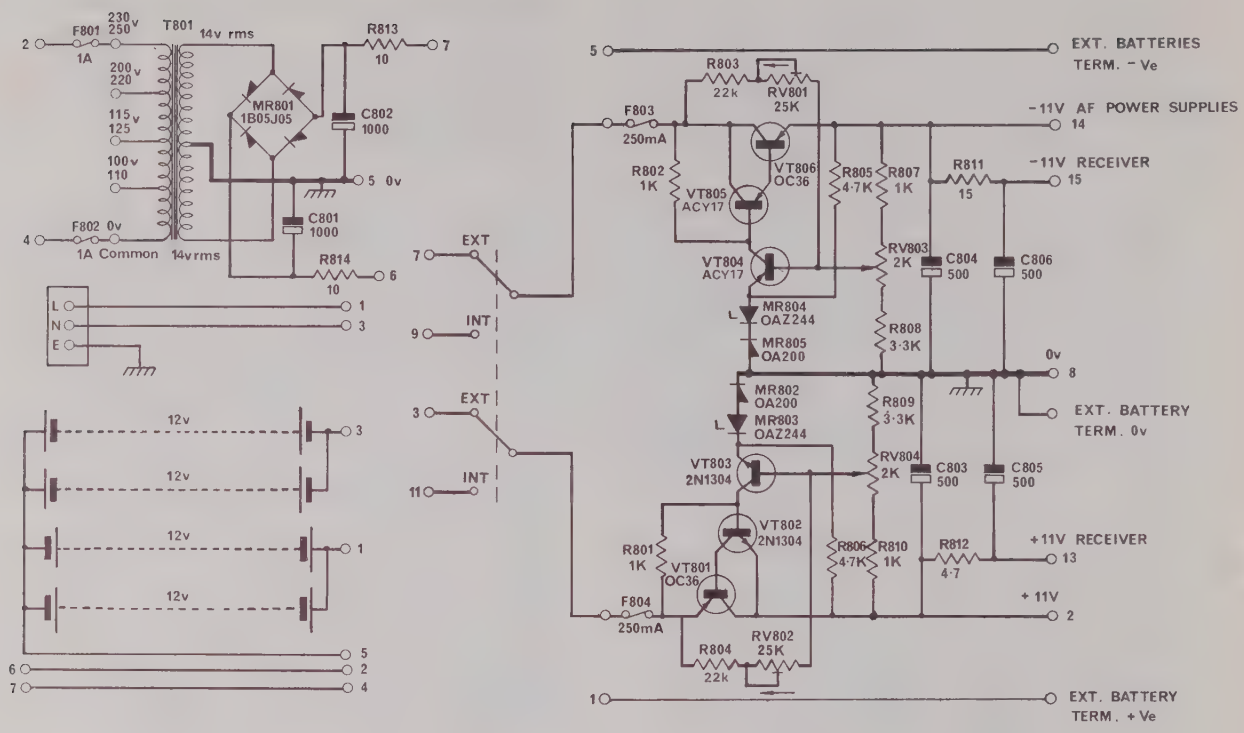


FIG.9 POWER SUPPLY UNIT DI2608/J

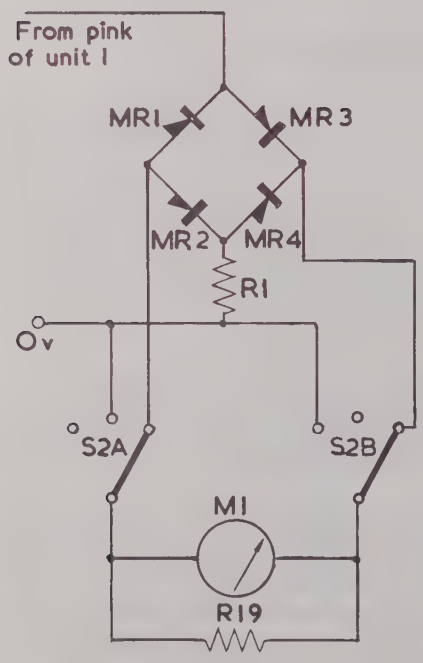


Fig.10a, Level checks

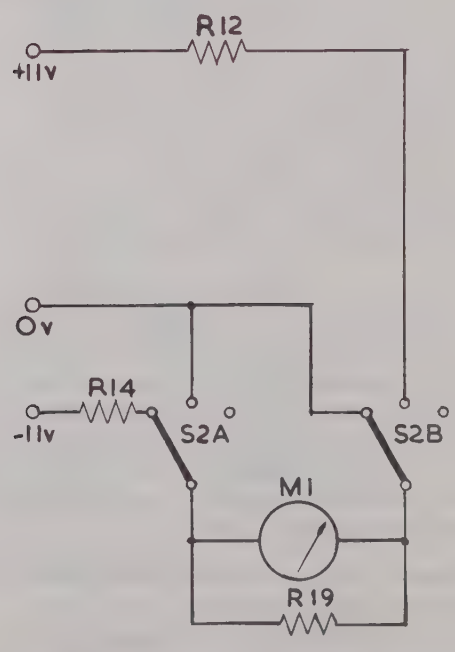


Fig. 10b, Supplies check

3 GP2: The −11V and +11V supplies are connected as for the GP1 setting of switch S5. Provision is made also for adjustment of the frequency of the oscillator in the glide path input circuit by disconnecting the link between pins 9 and 11 of PL702 and taking 0V to pin 9 through switch section S5C.
Additional smoothing of the +11V and −11V supplies fed through switch sections S5D and S5E is provided by capacitors C1, C2, C3 and resistors R13, R16.

Localiser input circuit (fig.11)

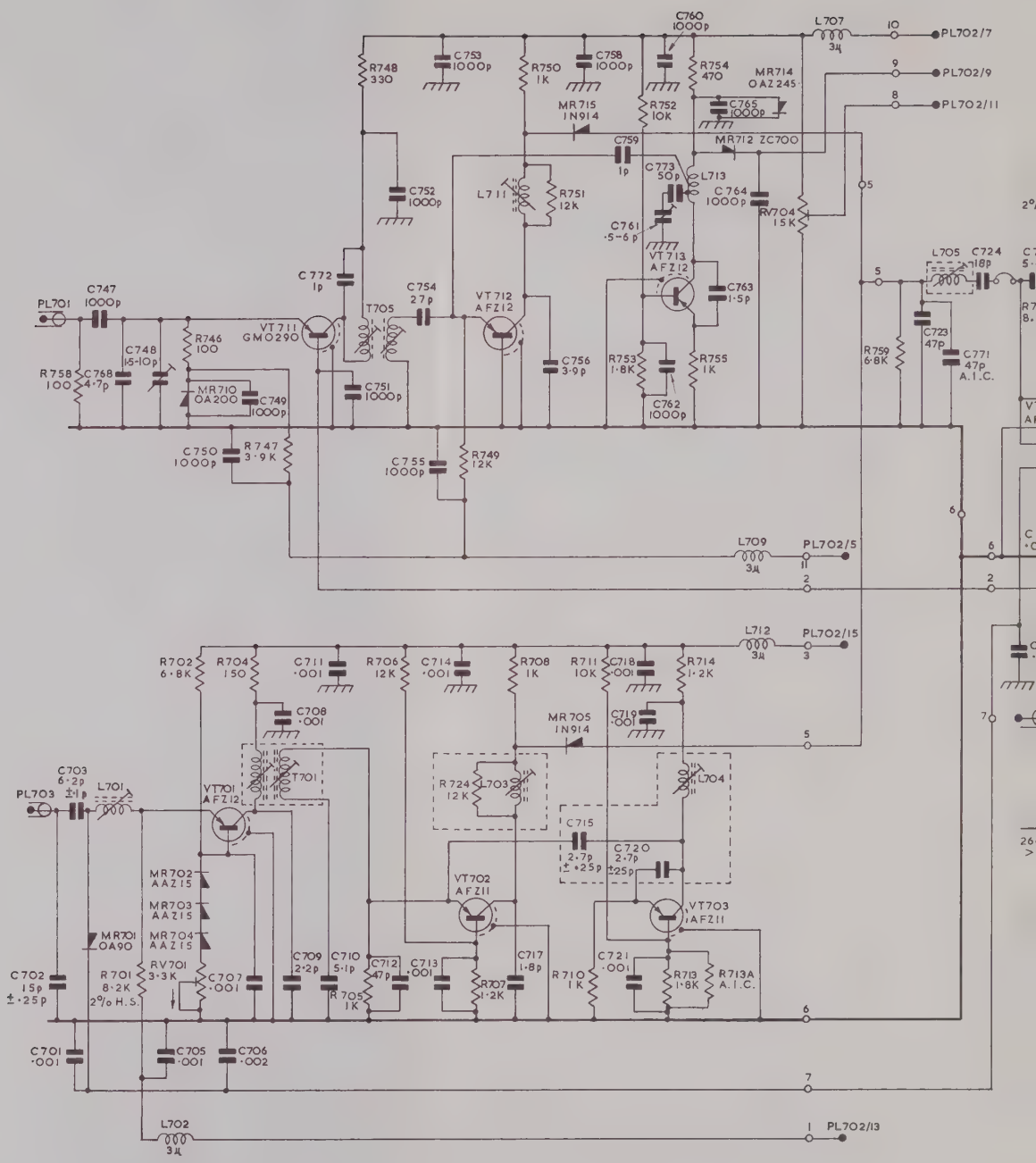
The 50 ohm localiser signal from the I.L.S. aerial is matched to the 110Mc/s resonant circuit, formed by inductor L701, capacitors C702, C703 and the input capacitance of transistor VT701.

The bias for the grounded base r.f. amplifier VT701 is provided by the potential at the junction of resistor R702 and diode MR702 and is determined by the setting of preset control RV701. Emitter current is supplied from the +11V line through resistor R701. At low levels of r.f. input the emitter potential of VT701, which is determined by the potential at the transistor base and its base to emitter potential, is more negative than the potential at the emitter of the a.g.c. control transistor VT704 so that diode MR701 does not conduct. As the r.f. input increases, the potential at VT704 emitter becomes more negative than the potential at VT701 emitter (see p.22) and diode MR701 begins to conduct thus increasing the damping on the input circuit. Further increases in r.f. level cause MR701 to conduct more heavily so that the current supplied to the emitter of VT701 decreases. The setting of RV701 determines the bias potential on VT701 and therefore the point at which a.g.c. control becomes effective in the r.f. amplifier stage. True matching of the 50 ohm impedance of the r.f. signal to the VT701 input circuit is obtained when the a.g.c. is not working.
The primary and secondary windings of VT701 collector load, transformer T701, are tuned by capacitors C709 and C710 respectively; capacitor C712 and resistor R705 provide secondary damping. The r.f. amplifier has a gain of 10dB and a double humped response. Grounded base amplifier VT702 operates as an additive mixer. Bias for the stage is taken from the junction of resistors R706 and R707 and emitter current is fed from the secondary of T701.
The 143Mc/s output from the oscillator transistor VT703 is added to the 108 to 112Mc/s incoming signal at the emitter of VT702 and the output at the mixer collector includes the i.f., i.e. the difference between the frequency of the oscillator output and the frequency of the incoming signal to the mixer.
The phase shift between the oscillator (VT703) collector and emitter is artificially increased by capacitor C720. Inductor L704 and coupling capacitor C715 form the tuned load on the collector of VT703, the frequency of oscillation being set at production by means of the dust core slug of the inductor.
The i.f. at the collector of the mixer VT702 is selected and passed to the input circuit of the i.f. strip by the mixer transformer L703, L705. The primary of the transformer, L703, is tuned by capacitor C717 and the coupling factor is determined by capacitor C723. The mixer transformer is split into L703 and L705 for convenience of printed circuit layout.

Glide path input circuit (fig.11)

The glide path input signal matching circuit comprises capacitors C747, C768, C748, together with R758 and the inductance of the input component leads and the input admittance of VT711. Resistor R747, which is effectively connected from the emitter of VT711 to ground with respect to a.c., damps the input circuit of VT711.

The bias for the grounded base r.f. amplifier VT711 is supplied from the wiper of preset control RV703 in the a.g.c. circuit. When the a.g.c. circuit is not working (see p.23), diode MR710 does not conduct and VT711 emitter current is supplied from the +11V line through resistor R747. As the r.f. input signal level increases and the a.g.c. circuit becomes operative, the bias potential of VT711 changes, diode MR710 begins to conduct and additional current is supplied to the emitter of VT711 through MR710. Increase in the emitter current beyond a certain point causes the stage gain to drop thus providing forward a.g.c. control for the stage. The point at which a.g.c. control becomes effective in the glide path r.f. amplifier stage is determined by the setting of RV703 in the a.g.c. circuit.
VT712 operates as a grounded base additive mixer and draws its emitter current from the +11V line through resistor R749. The 297 or 301Mc/s signal from oscillator transistor VT713 is added to the 328 to 333 or 332 to 336Mc/s incoming signal at the emitter of VT712. The output at the mixer collector includes the signal at the i.f., which is equal to the difference between the two frequencies fed to its emitter.
The phase shift between the collector and emitter of the oscillator VT713 is artificially increased by capacitor C773. The load on VT713 consists of a hairpin inductor L713 which is tuned by the combination of coupling capacitor C759, oscillator tuning capacitors C757, C761 and variable capacitor diode MR712. With the Input switch set to GP2, i.e. with 0V connected to PL702/9, capacitor C761 is ad-



justed for an oscillator frequency of 301Mc/s. By turning the input switch to GP1, so that PL702/9 and PL702/11 are connected, the potential across the diode and its capacitance are increased and preset control RV704 is adjusted for an oscillator frequency of 297Mc/s.

The i.f. at the collector of VT712 is selected and passed to the input circuit of the i.f. strip by the mixer transformer L711, L705. The primary winding L711, is tuned by capacitor C756 and the coupling factor is determined by capacitor C723.

I.F. circuit (fig. 11)

C724 is the tuning capacitor for the secondary winding L705 of the mixer transformer and feeds the signal from the localiser and glide path input circuits to the base of the a.g.c. control transistor VT704.

Bias for VT704 is supplied from the output stage of the a.g.c. control circuit. Transformer T702 forms the load on VT704 collector, neutralisation for the stage being provided by capacitor C726. Secondary tuning and damping of T702 are provided by capac-

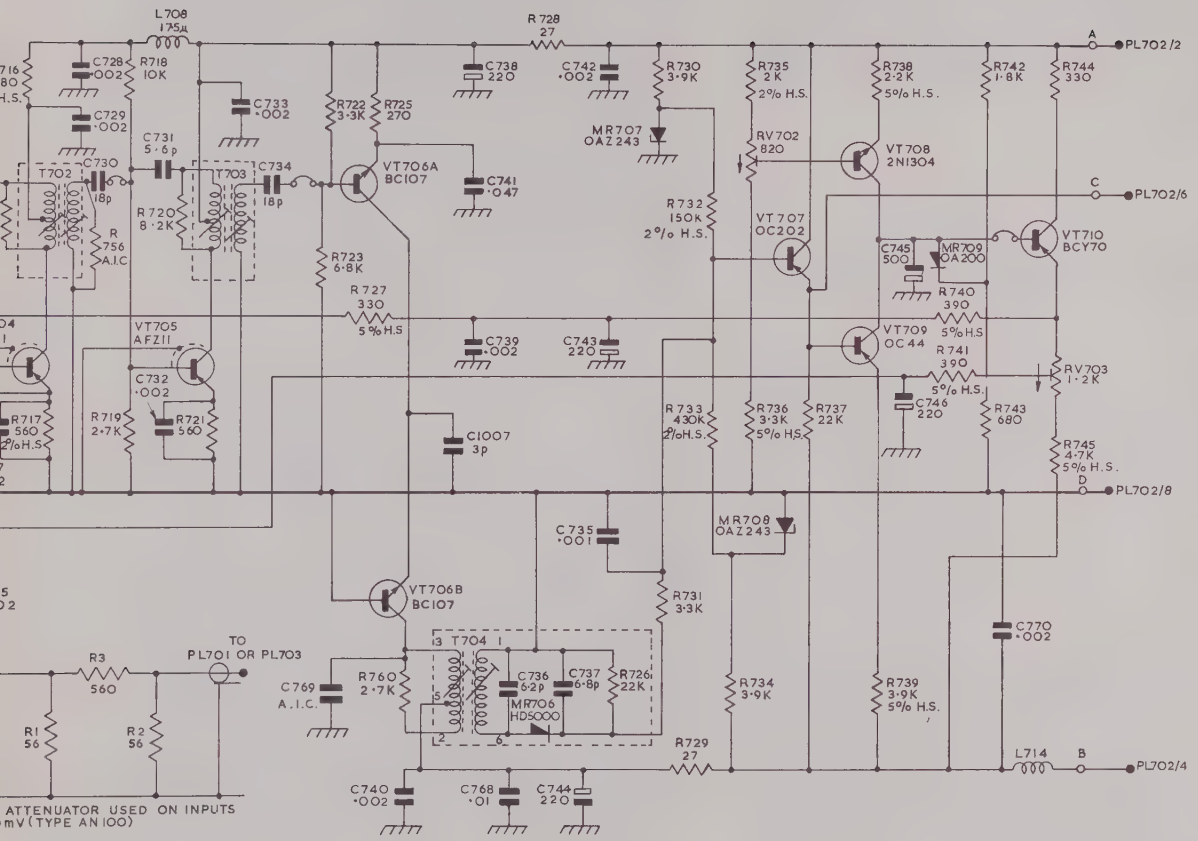


FIG.11 RECEIVER D12861/U

itor C730 and resistor R756. As the r.f. level increases, the potential at the emitter of VT710 in the a.g.c. control circuit and the bias on VT704 become more negative. VT704 emitter current therefore increases causing the emitter potential to become more negative so that the a.g.c. control in the localiser input circuit is initiated (see p.21). A constant output level from VT704 is maintained by forward a.g.c., the stage gain decreasing as the emitter current increases. The stage is designed to have a double humped response characteristic with a gain of over 20db and a bandwidth of 6Mc/s.

Transistor VT705 has fixed bias supplied from the junction of R718 and R719 but the stage is, in other respects, similar in design to the a.g.c. control stage VT704.

The output stage of the i.f. circuit comprises the cascode amplifier stage VT706A and VT706B. This arrangement gives a high gain without the need for neutralization.

The use of the npn silicon transistors in the cascode stage ensures linear power transfer.

The secondary winding of the load transformer T704 is tuned by C736 and feeds the low capacitance silicon diode detector MR706. Bias for MR706 is supplied from the junction of resistors R732 and R733, which are connected across the stabilised potential between zener diodes MR707 and MR708; the values of the resistors are high to prevent loading on the detector diode and thus maintain the linearity of power transfer from the stage. Smoothing of the detected signal is provided by capacitor C737 and resistor R726 damps the secondary response of T704. The detector output is fed to unit 1 through emitter follower VT707 and PL702/6 of the receiver plug. Loading of the detector is prevented by resistor R737, which keeps the emitter current of VT707 to approximately ½mA. The detector characteristic is given in fig. 12a.

A.G.C. circuit (fig. 11)

Transistors VT707 to VT710 form the a.g.c. circuit. The base of VT709 is supplied by the detector output at the emitter of VT707. The signal is amplified and its phase shifted through 180° by VT709. Transistor VT708 operates as a constant current load on VT709 collector, the value of the constant current being determined by the base potential of VT708, which is adjusted by preset control RV702. Capacitor C745 is charged instantaneously by the constant current transistor VT709 as the r.f. input level is increased and discharged instantaneously as the r.f. input level is decreased. Diode MR709 prevents the collector of VT709 from rising above 2V in a positive direction. Transistor VT710 is an emitter follower giving a low impedance output.

The localiser input a.g.c. signal is supplied from the emitter of transistor VT710 through the control transistor VT704 whilst the glide path a.g.c. signal is taken from the correct level at the wiper of RV703. The receiver a.g.c. characteristic is given in fig. 12b.

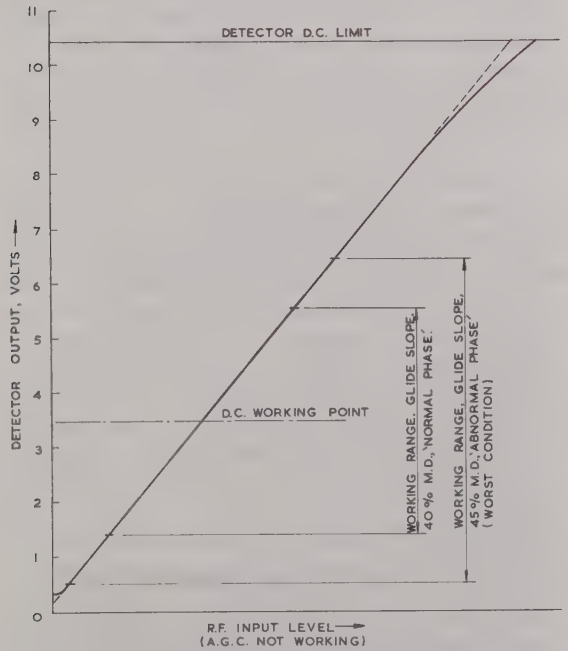

DETECTOR D.C. LIMIT
DETECTOR OUTPUT, VOLTS
D.C. WORKING POINT
WORKING RANGE, GLIDE SLOPE, 40% M.D., 'NORMAL PHASE'
WORKING RANGE, GLIDE SLOPE, 45% M.D., 'ABNORMAL PHASE' (WORST CONDITION)
R.F. INPUT LEVEL
(A.G.C. NOT WORKING)

FIG. 12a. DETECTOR CHARACTERISTIC (LOC & G.P.)

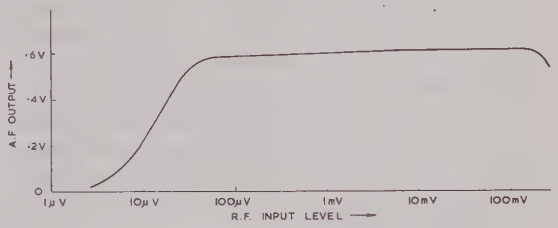


FIG.12b. RECEIVER A.G.C. CHARACTERISTIC, 110 Mcls.

Buffer amplifier and multiplier unit 1 (fig. 13 and unit interconnection diagram)

In the r.f. settings of the Input switch S5, the receiver output is connected through the Set R.F. control RV6 and switch section S5A to pin S on unit 1 plug. The signal from the receiver comprises the 90c/s and 150c/s tones at a d.c. level determined by the carrier amplitude. The r.f. level is adjusted by means of RV6.

With Input switch S5 set to A.F., the I.L.S. a.f. signal is fed through the Set A.F. Control RV5 and switch section S5A to pin S on unit 1 plug. RV5 is used to adjust the level of the a.f. signal input to the receiver.

Buffer stage

Emitter followers VT111 and VT101 provide a high input impedance buffer stage for the incoming signal at pin S of unit 1. The base potential of transistor VT102 is maintained constant by zener diode MR101 and the transistor forms a constant current load on the emitter of VT101 to give optimum linearity of output from the stage. In the case of r.f. input, the d.c. component of the buffer stage output signal is fed from the emitter of VT101 to pin P of the unit plug and to:

1 The modulation depth measurement potentiometer

chain. The chain comprises preset control RV3, resistor R6, Modulation Depth control RV2 and resistor R7 (see unit interconnection diagram) and is connected to 0V through switch section S5F and preset control RV1 or RV8. In the Mod Depth setting of the Function switch S4, the d.c. signal at the wiper of RV2 is fed to meter M2 through switch section S4E.

2 Monitor socket SKT1 on the front panel.

Buffer amplifier (fig. 13)

The a.f. signal at the emitter of VT101 is fed to the virtual earth amplifier VT103 to VT108 through input resistors R104, RV101 and R125.

The signal at the wiper of RV101 is taken through capacitor C102 to pin L of the unit plug. When the Calibrate switch S3 is depressed, pin L is connected to 0V and the input signal is slightly attenuated, the effect on the 150c/s component being greater than on the 90c/s component. This signal attenuation can be used for calibration of the instrument, see Appendix 6, p.51.

Transistors VT103, VT104 are connected as a feedback amplifier. Resistor R107 and capacitor C103 form a local feedback loop and shape the h.f. portion of the amplifier characteristic. Capacitor C104 provides output h.f. stabilisation. The output transistors VT105, VT107 have constant current loads formed by transistors VT106, VT108 to ensure linearity over the 6V peak to peak output swing. R108 is the overall feedback resistor.

In the A.F. and Loc settings of the Input switch S5, pin R of the unit plug is connected to 0V through switch section S5B. When switch S5 is set for glide path input, pin R is disconnected from 0V and connected to pin F of the unit plug. R124 is then connected in parallel with R108. The amplifier therefore has two gain conditions as follows:

1 At the a.f. and localiser settings of the Input switch S5, the gain is
R108/(R104 + RV101) = 13k/5.4k = 2.5.

2 At glide path settings of S5 the gain is halved by the parallel connection of R108 and R124 and is 6.5k/5.4k = 1.25.

The input impedance to the buffer stage is greater than 500k and the output impedance of the buffer amplifier is less than 1 ohm. The gain stability of the buffer amplifier is determined entirely by the input and feedback resistors in the circuit.

Output from the emitter of VT107 is taken:

1 Through series capacitors C107, C108 to pin K on the unit plug. The signal is applied across bridge rectifier MR1 to MR4 (unit interconnection diagram and fig.10) and the d.c. output of the rectifier is fed to meter M1 through switch sections S2A and S2B when the Supplies switch S2 is set to Level. The provision of a separate output for this signal prevents loading of the output terminal F by the bridge rectifier circuit.

2 Through series capacitors C105, C106 and pin F to unit 3.

3 Through C105, C106 and transformer T101 to the switching transistors VT109, VT110 (P1).

4 Through C105, C106, the sync. pulse filter (fig. 13a) and pin T to unit 6.

Multiplier (fig. 13)

The multipliers used in the N100 are balanced push pull transistor switches operated by square wave switching signals. The output from a simple transistor switch having an input signal cos $\omega_2 t$ and switched by a square wave signal sin $\omega_1 t$ contains sum and difference terms with all odd harmonics of the fundamental frequency ω_1 of the switching waveform together with the odd harmonics themselves, e.g. the output is of the form:

$$\sin(\omega_1+\omega_2)t+\sin(\omega_1-\omega_2)t+\tfrac{1}{3}[\sin(3\omega_1+\omega_2)t+\sin(3\omega_1-\omega_2)t]+\tfrac{1}{5}[\sin(5\omega_1+\omega_2)t+\sin(5\omega_1-\omega_2)t]+\ldots\ldots$$

$$+k[\sin\omega_1 t+\tfrac{1}{3}\sin 3\omega_1 t+\tfrac{1}{5}\sin 5\omega_1 t]+\ldots\ldots$$

A balanced switch, such as VT109, VT110 of fig. 13, removes the second set of terms but leaves a large number of unwanted components. However, none of the unwanted components has a frequency close to the sum and difference frequencies of the fundamental in the case of the N100 instrument and their presence can be ignored.

The transistors are either on or off so that they present either a short circuit or an open circuit to the following stage and the transistor parameters do not affect the circuit. The multipliers have excellent gain stability.

The multiplier (P1) comprises transformer T101 and switching transistors VT109, VT110. The antiphase 120c/s switching waveforms are applied to the bases of VT109 and VT110 from the reference signal chain through pins A and B on the unit plug, C111, R122, C112, R123 and restoring resistors R118, R120. The incoming signal from T101 secondary, comprising the 90c/s and 150c/s tones, is switched in the phase sensitive detectors and the multiplier output appears across R119 and is partially smoothed by C109, R128, RV102, R126 and C110. The 30c/s signal phase shift is adjusted at production by preset control RV102. The output, which is fed to pin C of the unit plug, depends upon the setting of the Function switch S4 as follows.

1 In the Set Null and D.D.M. functions, VT109 and VT110 are switched by the quadrature 120c/s reference; the multiplier output, assuming no error in the phase of the 120c/s reference, contains a 30c/s signal proportional to the difference of the amplitudes of the 90c/s and 150c/s tones,

i.e. (A–B) $\sin\omega_m t$. See Appendix 2.1.

2 In the Phase and Mod Depth functions, VT109 and VT110 are switched by the in-phase 120c/s reference; the output of the multiplier, assuming no error in the reference signal phase, contains a 30c/s signal proportional to the sum of the amplitudes of the 90c/s and 150c/s tones, i.e. (A+B)$\cos\omega_m t$. See Appendix 2.2.

The unsmoothed output from the multiplier is taken to test point TP1 at the rear of the instrument through pin E of the unit plug.

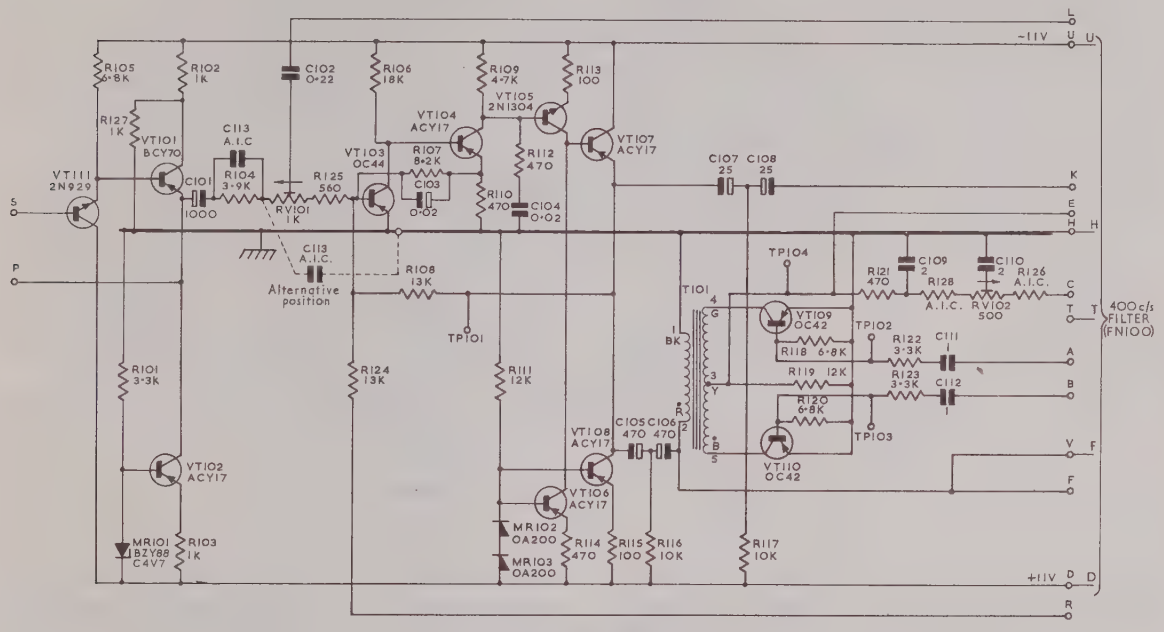


FIG.13 BUFFER AMPLIFIER AND MULTIPLIER (UNIT 1)
D12601/T

Sync Pulse Filter - Early models only (fig.13a)

The sync pulse filter is an active circuit comprising the transistors VT900 and VT901. Normally, the input to the filter is the double-tone sine wave shown in fig.28 Pt.2 and, in this case, the circuit acts merely as a noise filter to give a clean input to the sync pulse generator. However, for calibration purposes in some circumstances, the input modulation is a single-tone square wave and this would not correctly operate the sync pulse generator. In this case, the line feeding the sync pulse filter is broken (by means of a link provided for the purpose - see fig. 43) and a double-tone square wave, derived from the same source as the single-tone square wave, is fed to the filter, which converts it to the necessary double-tone sine wave.

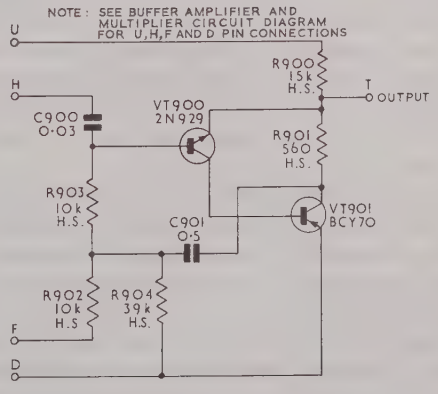


FIG.13a 400 c/s PULSE FILTER
D12160/C

30c/s amplifier and phase sensitive detectors, unit 2 and meter circuit (figs. 14, 15 and unit interconnection diagram)

The complex waveform fed to the 30c/s amplifiers from pin C of unit 1 plug has an amplitude of approximately 4V peak to peak. The waveform contains a 30c/s component having an amplitude of a few mV peak to peak and major components of 210c/s (120 + 90) and 270c/s (120 + 150). The 30c/s amplifiers are required to extract the small 30c/s component and provide sufficient attenuation of the major components to prevent them reaching the 30c/s phase sensitive detectors and causing errors in a.d.m. measurement by combining with the seventh and ninth harmonics of the 30 c/s switching waveform.

Wien bridge filters (fig. 14)

Two Wien bridge filters connected in series provide the required attenuation of the 210c/s and 270c/s components of the input signal to the 30c/s amplifiers. The basic circuit of the Wien bridge filter is given in fig. 14a. The circuit uses a current amplifier feeding into a Wien bridge.

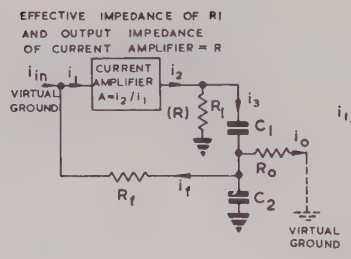


FIG. 14 a.

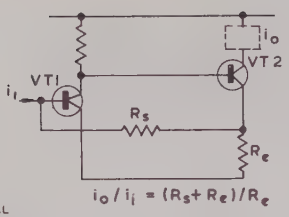


FIG. 14 b

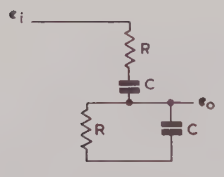


FIG. 14 c.

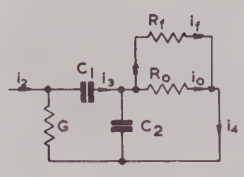


FIG 14 d.

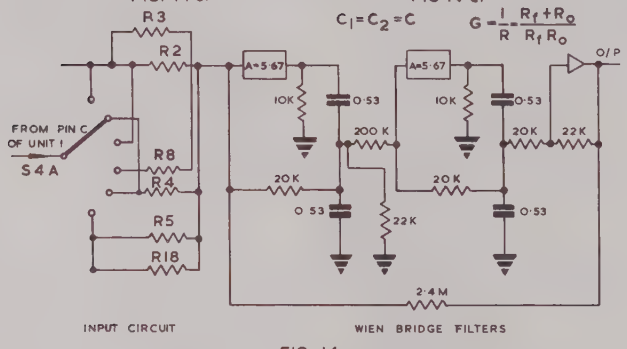


FIG. 14 e.

FIG. 14. WIEN BRIDGE FILTER

A simplified circuit of the current amplifier is given in fig. 14b. VT1 is a germanium transistor and VT2 a high gain silicon transistor to give the amplifier a low input impedance of the order of 10 ohms and a high output impedance of the order of 3 megohms. The amplifier has an open loop current gain of 2000 which is reduced to just below 6 by feedback resistors R_e and R_s.

Resistor R_1 (fig. 14a) shunts the high output impedance of the current amplifier to provide an effective output impedance of R. The impedance R is connected in series with capacitor C_1 (capacitance value C) to form the upper series leg of a Wien bridge. (See fig. 14c for the basic circuit of the Wien bridge). Resistors R_f and Ro are effectively in parallel because R_f is connected to the virtual ground input of the first stage and R_o to the virtual ground input of the second stage. Positive feedback is applied through R_f. The total resistance of R_f and R_o in parallel is R; the resistance R in parallel with the capacitance C of capacitor C_2 form the parallel arm of the Wien bridge. The closed loop voltage gain of such a circuit is 5.67 and its gain at resonance is 17, see Appendix 4. Two such stages are used in series to provide the necessary attenuation of 55db for the 210c/s component of the input signal. A simplified circuit of the two series Wien bridge filters and the input circuit is given in fig. 14e. The full circuit diagram of the 30c/s amplifiers is given in fig. 15. As the 30c/s amplifiers have a very low input impedance the voltage gain of the first stage is defined by the series input resistor. Function switch S4 selects this input resistor and the waveform from pin C of unit 1 plug is fed to pin B of unit 2 plug through switch section S4A and the selected resistor (R2 to R5, R18), see system diagram and fig. 14e.

The first Wien bridge amplifier VT201, VT202, has a forward current gain defined by resistors RV201, R205, R207, fig. 15. The effect of any drift in R205 and R207 is magnified by the positive feedback applied and they are therefore high stability metal film resistors. The series leg of the Wien bridge section is formed by 10k resistor R206 and the 0.53 microfarad capacitor C202. Positive feedback is applied through resistor R204 and the output signal of the stage is fed to the virtual ground provided by the low input impedance of the second Wien bridge filter through resistors R208 and R209 in parallel. Resistor R204 is effectively in parallel with R208 and R209 to provide a total resistance of approximately 10k; the parallel combination of these resistors with the 0.53 microfarad capacitor

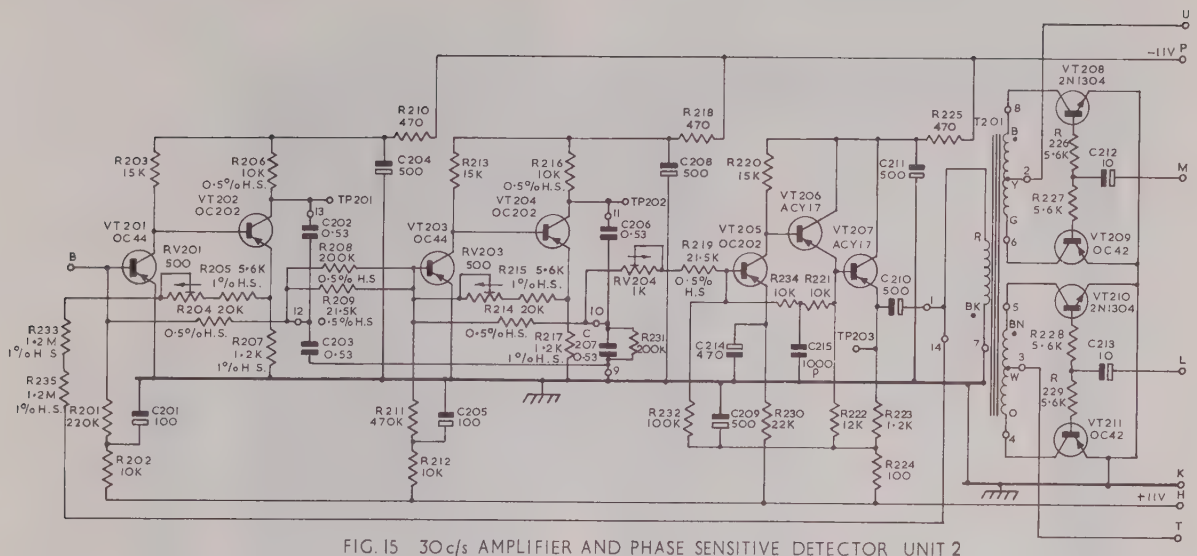


FIG. 15 30c/s AMPLIFIER AND PHASE SENSITIVE DETECTOR UNIT 2
D12602/N

C203 forms the parallel leg of the Wien bridge. C202 and C203 are high stability metal cased polystyrene capacitors and the Wien bridge resistors are wirewound and have a positive temperature coefficient of resistance to balance as nearly as possible the negative coefficient of the capacitors. Preset potentiometer RV201 is used to trim the Q and gain of the amplifier. The amplifier bias is taken from the +11V line through resistor R201 and decoupling components R202 and C201.

The second amplifier is almost identical with the first and its output signal is fed through preset control RV204 and resistor R219 into the output amplifier VT205, VT206. The output amplifier has a very low input impedance and presents a virtual ground to the incoming signal. RV204 is a trimming control for resonant frequency and thus for the 30c/s phase. Feedback is provided through resistor R221 and determines the voltage gain of the amplifier, which is unity. The output of the amplifier is taken through emitter follower VT207 and transformer T201 to the 30c/s phase sensitive detectors VT208 to VT211.

Overall negative feedback from the output of the emitter follower VT207 to the input to the three amplifiers is provided through resistors R233 and R235. This feedback reduces the overall gain by a factor of 4.5 but flattens the frequency response peak and reduces the change of 30c/s phase with frequency. The overall feedback also allows a one per cent gain stability to be maintained under conditions of temperature change, ageing and drift of variable resistors. Fine adjustment of the overall gain is provided by the gain controls RV201 and RV203 in the Wien bridge amplifiers.

Even a small spurious 30c/s signal at the input to the amplifier system can cause appreciable error; each stage of the amplifier system is therefore decoupled from both the −11V and +11V lines. Fig. 16 shows the characteristic response from the amplifier system; the response is flat over the range 29.5 to 30.5c/s and the attenuation at 210c/s is 65db.

Phase sensitive detectors (fig. 15)

The two secondary windings of T201 provide input signals to the phase sensitive detectors VT208, VT209 and VT210, VT211. Of the two transistors forming each phase sensitive detector one is npn and the other pnp, the transistors acting in push pull so that a single phase switching waveform can be used. This waveform is the 30c/s reference fed from the reference signal chain through pins M and L of unit 2 plug and capacitor C212, resistors R226, R227 and capacitor C213, resistors R228, R229 to the bases of the switching transistors.

The quadrature 30c/s reference fed to pin L switches phase sensitive detector VT210, VT211 (P2) and its output is fed through pin T of unit 2 plug and switch section S4D:

1 To meter M2 when the Function switch S4 is set to Phase. The d.c. signal registered by M2 is approximately proportional to (A+B) sin θ and, is reduced to zero by correcting the error θ in

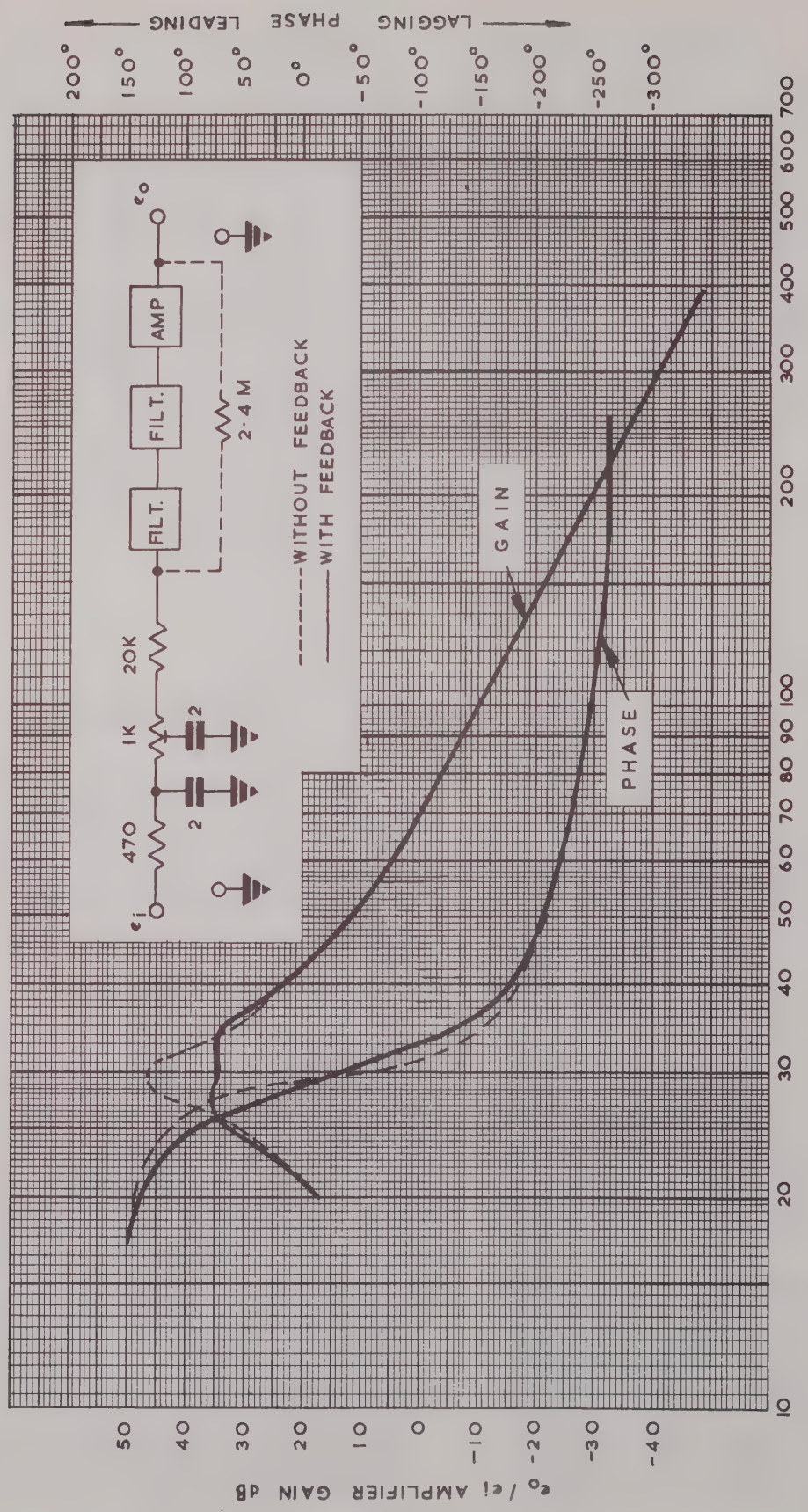


FIG. 16. 30 cls FILTER AMPLIFIER CHARACTERISTICS.

the phase of the common source of the 30c/s reference. See Appendix 3.1.

2 To meter M2 when the Function switch is set to D.D.M. The d.c. signal applied to M2 is proportional to A–B and the meter is calibrated to read percentage d.d.m., see Appendix 3.4.

The 30c/s reference at pin L is fed to test point TP2 at the rear of the instrument.

The in phase 30c/s reference fed to pin M switches phase sensitive detector VT208, VT209 (P3) and its output is taken through pin U of unit 2 plug and switch section S4F:

1 To meter M3, when the Function switch S4 is at Set Null or D.D.M. The d.c. signal registered by M3 is proportional to (A+B) sin ϕ and is reduced to zero by correcting the error ϕ in the phase of the 120c/s reference. See Appendix 3.2.

2 To meter M2, when the Function switch is set to Mod Depth. The d.c. signal proportional to A+B is opposed by the d.c. signal proportional to the carrier amplitude fed to the meter from unit 1 through the wiper of the Modulation Depth control RV2 and switch section S4E. The percentage modulation depth is read on the dial of RV2 when the control is adjusted for zero meter reading. See Appendix 3.3.

The 30c/s signal at pin M can be monitored at test point TP3 at the rear of the instrument.

Switch section S5F completes the modulation depth measurement chain RV3, R6, RV2, R7 through preset control RV1 or RV8 depending upon the function selected (see unit interconnection diagram).

Meter circuit (unit interconnection diagram)

Resistors R9 and R20 determine the meter M2 sensitivity. Resistor R22 is brought into circuit by depressing the ÷2 switch S7 and reduces the sensitivity of meter M2 to exactly one half. The diodes MR5 and MR6 give overload protection for meter M2. Resistors R10 and R11 determine the sensitivity of meter M3. JK1, JK3 and SKT4 to SKT7 are the Monitor D.D.M. and Monitor Null jacks and sockets at the rear of the instrument.

Meter M2 is calibrated by setting the Function switch to Mod Depth and depressing the Calibrate switch. The d.c. proportional to carrier amplitude from the wiper of the Modulation Depth control is then disconnected from meter M2 and a calibration signal is fed from the wiper of preset control RV9 in the potential divider across the +11V supply formed by R21 and RV9. The Set Level control is then adjusted for zero meter M2 reading. See Appendix 6, p.51.

90c/s and 150c/s filter and squarer, and Summing Amplifier unit 3 (figs. 17, 18)

The a.f. signal containing the 90c/s and 150c/s tones is fed from pin F of unit 1 plug to pin A of unit 3 plug. The 90c/s filter consists of a 150c/s notch filter VT301, followed by a push pull amplifier VT302, VT303, VT304, VT305. Its output is fed into a 90 c/s squarer, IC301, a high gain amplifier whose output is clipped and coupled to a 90 c/s tuned filter comprising a Wien bridge network across IC302. The 150 c/s filter is similar to the 90 c/s filter but is followed by a Wien bridge circuit to give the extra filtering required for a pure sine wave output. The squarer VT313, VT314, VT315 following the Wien bridge circuit requires a pure sine wave input to produce a square waveform output having an accurate 1:1 mark space ratio.

The notch filter (fig. 17)

A perfect notch filter has an infinite attenuation at one frequency only, and a response of the form shown in fig. 17a. A method of obtaining such a response is illustrated in fig. 17b. The input signal is fed to a network having a peaked response with zero phase shift at the peak. The output of the network is subtracted from the input signal in the mixing network, the gains being chosen so that the two signals exactly cancel and practically infinite attenuation is achieved.

Fig. 17c shows the basic circuit of a system operating in the manner shown in fig. 17b. The peaked network, with no mixing resistors connected, has a frequency response:

$$\frac{e_2}{e_1} = \frac{0.1 + 1.1\,RpC}{1 + 2RpC + R^2p^2C^2}$$ (See Appendix 5)

when $R_1 = R_2 = R$, $R_3 = 10R$ and $C_1 = C_2 = C$.

By choosing values for the mixing resistors R_4, R_5 so that $e_o = e_1 + 1.82e_2$, the response of the circuit becomes:

$$\frac{e_o}{e_1} = \frac{0.82 + R^2C^2p^2}{1 + 2RCp + R^2C^2p^2}$$ (See Appendix 5)

This is the response of a perfect notch having a slightly skew characteristic.

The tolerances in the values of the components used affect the attenuation achieved by the network at the desired frequency. The mixing ratio R_4/R_5 is adjusted using RV_2. The mixing resistor R_4 will slightly affect the time constant R_2C_2 but this effect is compensated by raising the value of R_2 so that $R_2R_4/(R_2 + R_4)$ gives the desired value. The notch attenuation is 30db minimum.

90c/s filter (figs. 17 and 18)

Fig. 18 is a circuit diagram of unit 3 and shows the peaked response network consisting of transistor VT301 and its associated components, and the mixing resistors R306, R307.

The a.f. input at pin A is fed through resistor R301 to the base of VT301. The signal at the collector of VT301 and a signal fed from the input at the base of VT301 are mixed in resistors R306, R307, preset control RV301 being adjusted for exact cancellation of the 150c/s signal.

The lag time constant C_2R_2 (fig. 17c) is provided by capacitor C304 and resistor R304 modified by R307. The lead time constant C_1R_1 (fig. 17c) is formed by the parallel combination of resistors R305, R308 connected in series with capacitor C305; resistor R303 provides correction of the lead time constant for component tolerances.

The signal at the wiper of RV301 is applied to the feedback amplifier VT302, VT303. The d.c. bias for VT302 is taken from the +11V line through resistor R309 and decoupling components R312, C302. The amplifier has a push pull emitter follower output provided by VT304, VT305. Feedback from the output of the emitter follower to the input of the push pull amplifier is provided through resistors R316, R310. The feedback is modified slightly by capacitor C306 to give a few degrees of phase advance to the 90c/s signal and thus assist later generation of a 120c/s reference in correct phase relationship with the incoming signal.

The 90c/s signal from the filter has a peak to peak amplitude of approximately 1.5V at zero D.D.M. and contains less than 100mV of the 150c/s tone. The signal is fed to the 90c/s squarer through capacitor C324 and resistor R350 whilst the d.c. coupled output through pin L is applied to test point TP4 at the rear of the instrument.

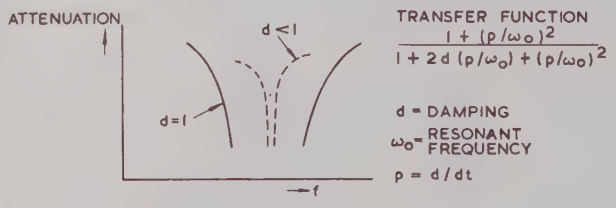


FIG. 17a NOTCH FILTER CHARACTERISTIC.

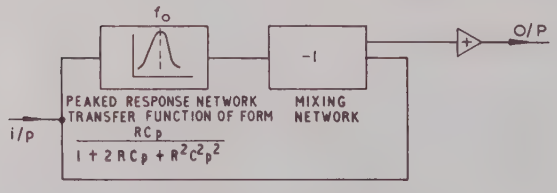


FIG. 17b METHOD OF OBTAINING NOTCH FILTER RESPONSE.

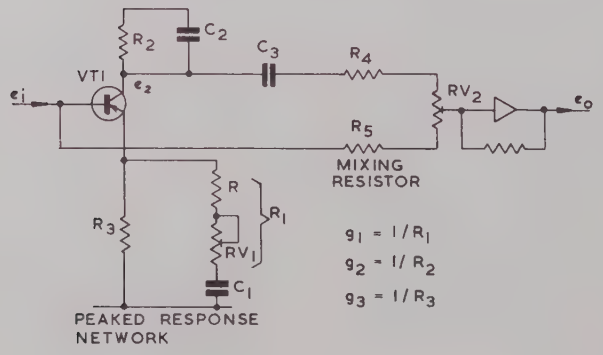


FIG. 17c SIMPLIFIED NOTCH FILTER CIRCUIT.

FIG. 17. NOTCH FILTER

90 c/s Squarer (fig. 18)

The 90 c/s squarer comprises a high gain IC amplifier IC301, with limiting diodes MR303 and MR304 connected between the input and output pins. A compensating capacitor C325 is connected between pins 1 and 8, stabilising the circuit. Diodes MR303 and MR304 chop the positive and negative swing of the 90 c/s signal from the filter, limiting the peak-to-peak amplitude of the output to -1V

90 c/s Tuned Filter (fig. 18)

Frequency sensitive positive feedback is applied to pin 3 of IC302 via a Wien bridge network R359, C329, RV304, R358 and C327. The bridge is completed by the negative feedback applied to IC302 through R357 and R353, R354. Input is applied through R352 to a point in the bridge which acts as a virtual earth at resonant frequency. The filter is tuned by RV304 to give a slight phase advance at 90 c/s and the output voltage is approximately 2V peak-to-peak, varying only slightly with D.D.M. This signal is fed to the 240 c/s reference generator and to the summing amplifier.

Summing Amplifier (fig. 18)

A 150 c/s squared output from VT315 is differentiated by C326, R356 and is added to the 90 c/s filtered signal via C332, R361 and fed to IC303 which operates as a summing amplifier. Signal phasing is modified by C330 shunting R360. A d.c. bias voltage derived from the +11V by R362, R363 is applied to pin 3 of IC303, providing a d.c. offset to the output signal. The resultant signal (fig. 28.28) feeds the synchronising circuits of unit 6.

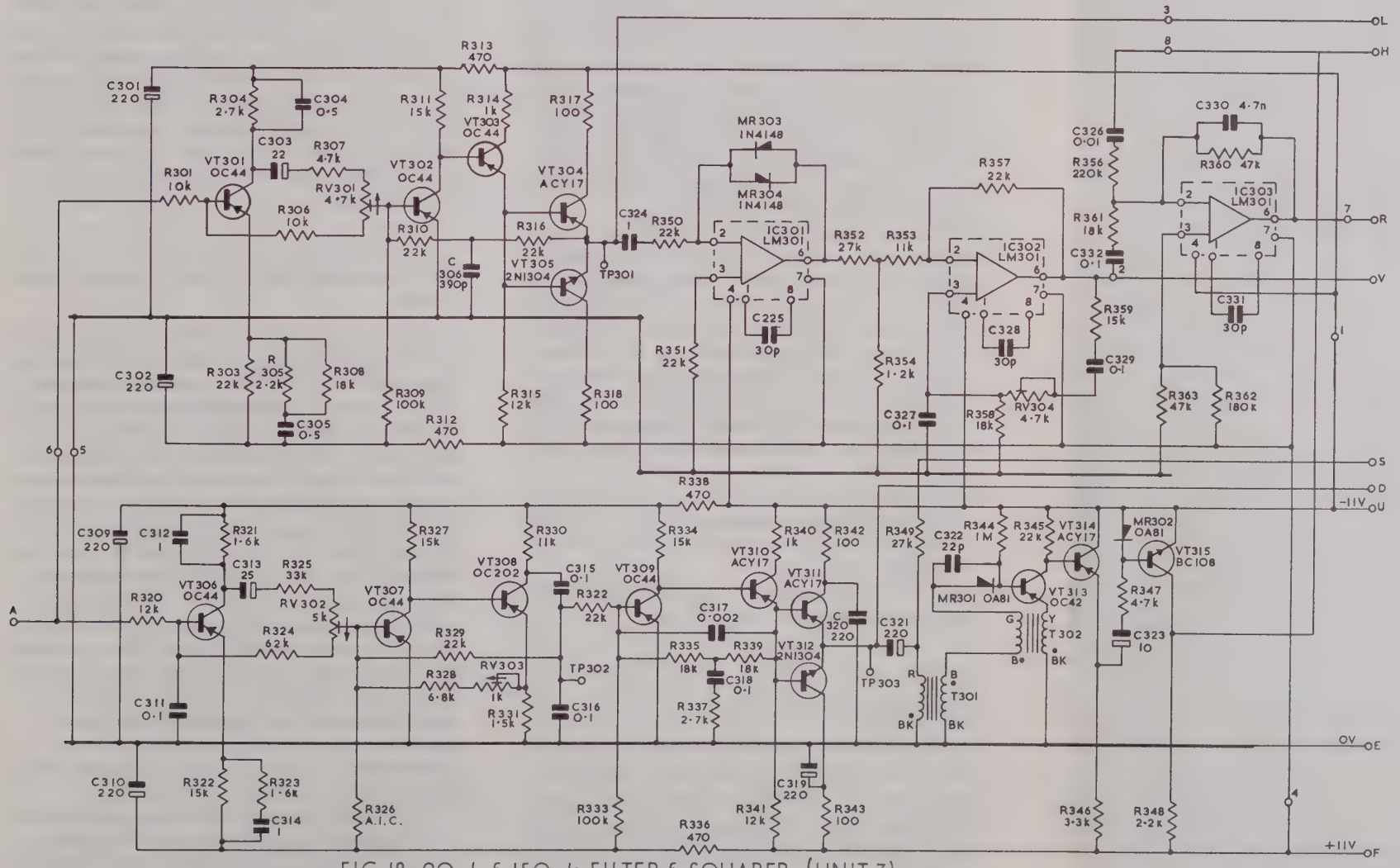


FIG. 18 90c/s & 150c/s FILTER & SQUARER (UNIT 3)
D12603/L

150c/s filter (figs. 17 and 18)

The 150c/s filter circuit comprises the notch filter stage VT306, mixing resistors R324, R325, Wien bridge filter VT307, VT308, and push pull amplifier VT309, VT310 working into the push pull emitter follower VT311, VT312. Apart from the differences in component values required to give cancellation of the 90c/s tone from the output signal and the inclusion of the Wien bridge filter of the type used in unit 2, the circuit of the 150c/s filter is practically identical with that of the 90c/s filter. Capacitor C312, resistor R321 (modified by mixing resistor R325) and capacitor C314, resistor R323 form the time constants C_2R_2 and C_1R_1 of fig. 17c. Potentiometer RV302 provides the notch filter adjustment. The mixing resistors in the 150c/s filter have a much higher value than R306, R307 in the 90c/s filter because the Wien bridge provides voltage gain.

Bias for the Wien bridge and push pull amplifier are taken from the +11V line through R326 and decoupling components R336 and C310. The open loop forward gain of the Wien bridge is defined by resistors R331 and R328 in series with preset control RV303, which is used to adjust the gain. The series Wien bridge arm is formed by components R330, C315 and the parallel arm by R329, R332 and C316. Positive feedback is applied through R329 and the feed to the next stage through R332.

The push pull output amplifier is of similar design to that included in the 90c/s filter and has negative feedback and phase correction through components R335, R339, C318, R337 and C317. The push pull emitter follower formed by transistors VT311 and VT312 has a low output impedance and feeds a 150c/s sine wave output, containing less than 50mV of the 90c/s tone, to the squarer circuit. The peak to peak amplitude of the output is adjusted to 4V by RV303 in the Wien bridge filter circuit. The output is fed to:

1 The squarer circuit VT313 to VT315 through capacitor C321 and transformer T301.
2 The reference generator, test point TP5 and terminal D of unit 3 plug.
3 The sync pulse generator through capacitor C321, resistor R349 and pin S of unit 3 plug.

150c/s Squarer (fig. 18)

The 150c/s squarer circuit is a form of the 'Multiar' circuit described in M.I.T. handbook entitled 'Waveforms'. Switching transistor VT313 is normally held in the conducting state by the bias applied through resistor R344 so that its collector is at 0V and its base at approximately -300mV. When the incoming sine wave is positive going and approaches 0V, diode MR301 begins to conduct and VT313 is cut off. The pulse produced in the primary of T302 during the switching phase assists the change already taking place due to the input sine wave and thus aids the cut off process.

The reverse effect occurs when the incoming signal approaches 0V in the negative going direction. The diode then ceases to conduct and VT313 switches on again, the switching process being aided by positive feedback through transformer T302. The actual point of switching in both directions is almost exactly 0V because, at that level, the forward diode voltage cancels the base to emitter voltage of the transistor. Thus, provided the incoming sine wave is undistorted, the final square wave will have an accurate 1:1 mark to space ratio.

The output at the collector of VT313 is passed through emitter follower VT314 to the base of switching transistor VT315, which conducts when its base is at 0V and is cut off when the input wave becomes positive. Thus VT315 inverts the incoming waveform at its base and switches it between +11V and 0V. The low impedance output from the squarer circuit has a large swing of 20V peak to peak and a rise and fall time of less than 1 microsecond. The square waveform is passed to the reference generator through pin H of unit 3 plug and can be monitored at test point TP6 at the rear of the instrument.

Reference generator unit 4 (figs. 19, 20 and system diagram)

A closed loop generator, fig. 19, is used to produce a 240c/s signal locked in phase to the incoming signal from the I.L.S. The closed loop comprises a 240c/s frequency controlled multivibrator (f.c.m.), two push pull switched transistor multipliers of the type described in p.24 and a simple two stage, low pass filter. The 240c/s signal from the f.c.m. is multiplied successively by the 90c/s sine wave and the 150c/s square wave signals from unit 3. The output from the second multiplier is a d.c. signal together with many other components of frequency 60c/s and upwards. The filter removes the a.c. components and passes the d.c. signal to the circuit which controls the multivibrator. The d.c. signal is reduced to zero when the f.c.m. output is correct in phase and frequency. The whole system works in a similar manner to the conventional phase-lock oscillator.

Two other d.c. signals also provide control of the multivibrator. These are:

1 A fine phase control signal taken from the Set Null potentiometer RV4, see fig. 19 and p.33.
2 A signal from phase sensitive detector P3 through an overall phase feedback loop, see fig. 21 and p.33.

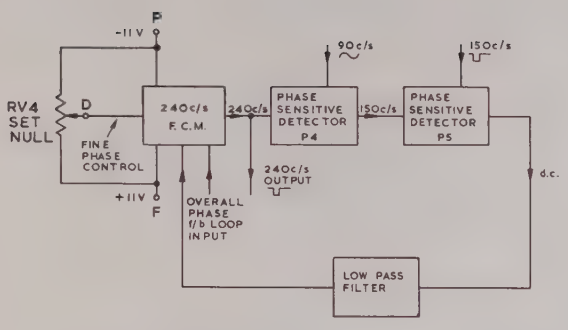


FIG. 19. CLOSED LOOP GENERATOR.

Frequency controlled multibibrator (fig. 20)

Switching transistors VT402, VT405, form the multivibrator circuit which is controlled by timing capacitors C403, C404 and the current source transistors VT403, VT404. Diodes MR407 and MR408 are included in the circuit to ensure that the timing capacitors discharge through resistors R403, R407 when the switching transistors are cut off and not through the collector loads R402, R408. The multivibrator outputs are taken from the collectors of VT402 and VT405 through emitter followers VT401 and VT406 to pins B and M of unit 4 plug.

The phase lock loop (fig. 20)

The output of the f.c.m. through emitter follower VT406 is amplified by transistor VT407 and applied to the bases of switching transistors VT409, VT410, which form the phase sensitive detector P4 of fig. 19. The 90c/s sine wave output from unit 3 is passed through pin A of unit 4 plug and transformer T401 to the collectors of VT409, VT410 and switched at 240c/s by the amplified output of the f.c.m., which is applied to the bases of VT409, VT410 through resistors R419, R420. The complex output of the multiplier, which contains a 150c/s signal, is passed through push pull emitter follower VT411, VT412 and transformer T402 to the collectors of transistors VT413, VT414, which form the second phase sensitive detector P5. The signal is switched in the multiplier by the 150c/s square waveform fed from unit 3 through pin K of unit 4 plug and resistors R423, R424 to the bases of VT413, VT414. The complex waveform at the centre tap of T402 secondary contains a d.c. signal.

The output of P5 is passed through the two stage low pass filter formed by R422, C408 and R421, C407 to remove unwanted components and provide a d.c. signal to the multivibrator control circuit through resistor R418 and emitter follower VT408. It is important that the power supplies to the f.c.m. should be extremely stable. The supplies are therefore separately stabilised at ±8.5V by zener diodes MR403, MR404, temperature compensation being provided by diodes MR401, MR402 and MR405, MR406.

F.C.M. control circuit (fig. 20)

The d.c. signal from the phase lock loop is applied to the bases of the parallel connected control transistors VT403, VT404. The signal controls the collector current of the transistors and therefore the charge time for capacitors C403, C404. The timing capacitors in the multivibrator circuit and the emitter resistors R404, R406 in the control circuit are close tolerance components and preset control RV402 provides fine control so that a 1:1 mark space ratio is obtained.

Coarse adjustment of frequency and phase of the multivibrator output is provided by preset control RV401. Fine adjustment is made by feeding a d.c. signal from the wiper of the Set Null control RV4 through pin D of unit 4 and emitter follower VT408 to the bases of the control transistors VT403, VT404. The Set Null control is connected across the 8.5V supply lines at pins P and F of unit 4 as shown in the simplified circuit of fig. 19.

Overall phase feedback loop (fig. 21)

A signal dependent upon the error in the phase of the 120c/s reference is fed from unit 2 to meter M3 through switch section S4F when the Function switch is at Set Null or D.D.M. This signal is also fed through the low frequency filter formed by resistor R17, capacitors C4 and C5 on the main chassis (system diagram), decoupling components R417, C406 in unit 4 and resistor R416, emitter follower VT408 to the bases of control transistors VT403, VT404 thus forming an overall negative feedback loop which reduces the phase error by approximately 5:1

Multivibrator starter (fig. 20)

Initial conditions may occur when the power supplies are switched on such that both switching transistors VT402 and VT405 are conducting at the same time and the multivibrator action does not commence. To obviate this effect a signal consisting of positive pulses of 30c/s repetition rate is fed to the emitter of control transistor VT404 to cut off the transistor during the pulse and thus switch off transistor VT402 in the multivibrator circuit. In this way the multivibrator action is started. The pulses from the starter circuit die away a few seconds after the I.L.S. signal is connected to the system. This precaution is necessary because, if

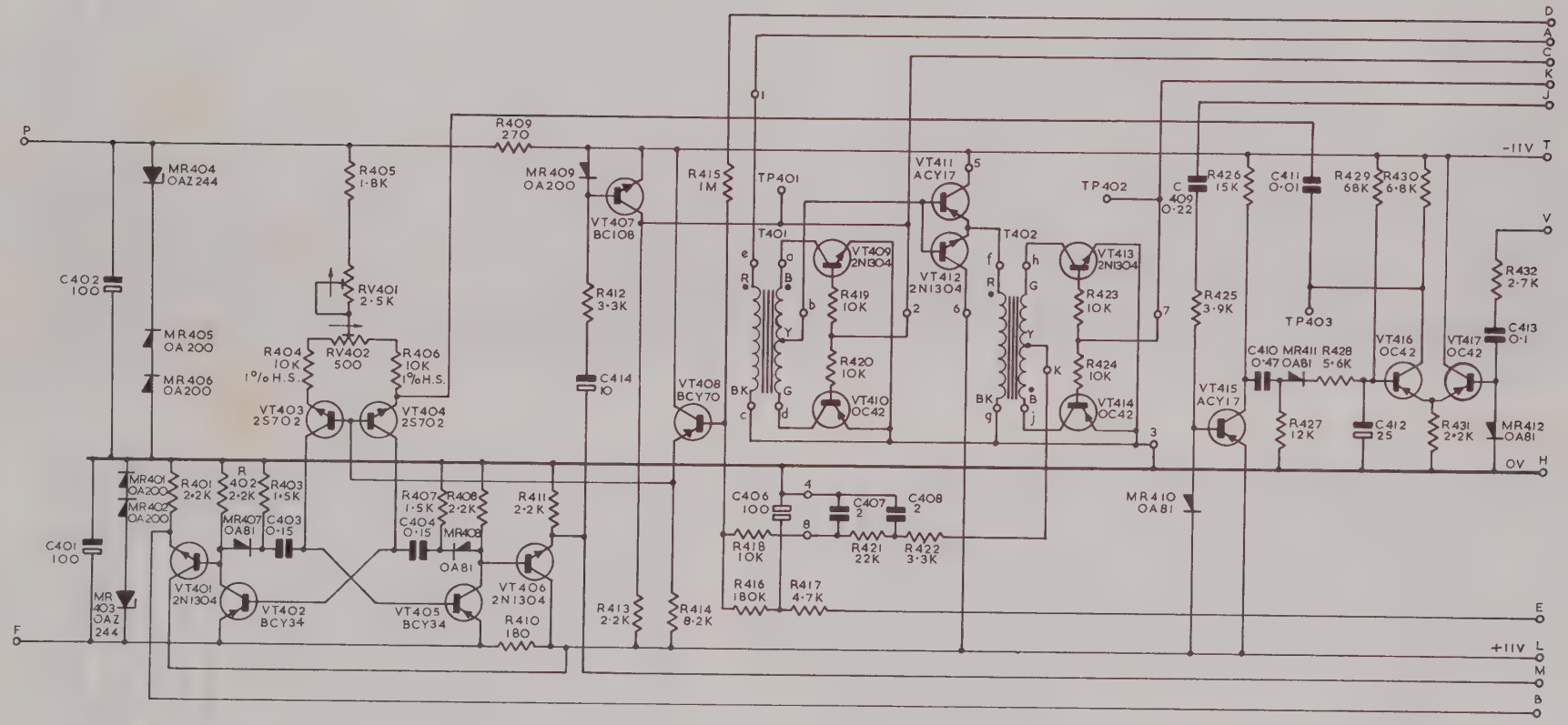


FIG. 20 REFERENCE GENERATOR (UNIT 4)
D12604/K

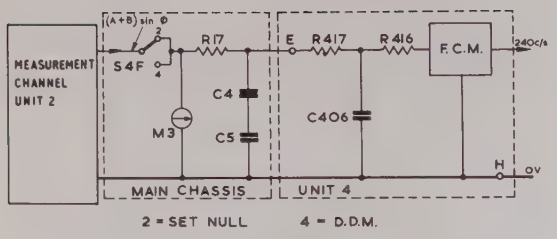


FIG. 21. OVERALL PHASE FEEDBACK LOOP.

the starter pulses were injected continuously into the f.c.m., its 240c/s output would be phase modulated by the 30c/s starter pulses and the 120c/s reference signal derived from these pulses would produce a spurious 30c/s signal in the 120c/s phase sensitive detector P1.

The starter circuit comprises transistors VT415, VT416 and VT417. The 150c/s sine wave from unit 3 is fed through pin J of unit 4 plug to the base of squaring transistor VT415 through capacitor C409 and resistor R425. The square wave at the collector of VT415 is applied to diode MR411 through capacitor C410. The d.c. signal produced charges capacitor C412 positively. The long tailed pair VT416, VT417 is normally maintained in the conducting state by the bias applied to VT416 through resistor R429 but is cut off when capacitor C412 charges. 30c/s pulses applied to pin V of unit 4 plug from the sync pulse generator unit 6, see p.38, are d.c. restored by diode MR412 and fed to the base of VT417.

Under initial conditions, before C412 has been charged and VT416 cut off, the 30c/s pulses at the base of VT417 are passed through the long tailed pair and capacitor C411 to the emitter of VT404 to initiate multivibrator operation. When the I.L.S. signal is applied to the system and unit 3 feeds a 150c/s sine wave to pin J of unit 4 plug, capacitor C412 charges and cuts off the long tailed pair so that the pulses at the collector of VT416 die away thus removing the multivibrator starting signal.

Binary unit 5 (figs. 22 to 24 and system diagram)

The input to the binary unit from the reference generator is the 240c/s (90c/s + 150c/s) square wave from the reference generator. The outputs required from the unit are:

1 Two quadrature 120c/s square waves locked in phase to the input.
2 Two quadrature 30c/s square waves locked in phase to the 120c/s reference, but with provision for manual adjustment of the phase of their common source.

The quadrature 120c/s references are produced from the antiphase 240c/s signals from the reference generator by division in binary circuits VT501, VT502 (B1) and VT503, VT504 (B2) in unit 5 (see fig. 22). The outputs from the collectors of the transistors are fed to pins P, S and H, J of unit 5 to provide the push pull switching operation required by the 120c/s phase sensitive detector P1.

The output from VT504 collector is passed through the phase shifter circuit comprising transistors VT506, VT507 and their associated components to binary divider VT508, VT509 (B3), which provides antiphase 60c/s signals at the collectors of the transistors. These 60c/s signals are divided in binary circuits VT510, VT511 (B4) and VT512, VT513 (B5). The quadrature, single drive signals required for switching the 30c/s phase sensitive detectors P2, P3 are taken from the collectors of VT511, VT513 through pins A and B of unit 5 plug.

The phase shift circuit incorporated in the unit compensates for the phase discrepancies introduced by production of the 30c/s signals from the 120c/s signal. The negative going sync pulses from unit 6, see p.3 7 are fed to each binary unit through pin C of unit 5.

Binary circuits (fig. 22)

The five binary circuits included in unit 5 are identical so that it is sufficient to describe one of them, for example, VT501, VT502.

VT501, VT502 are switching transistors triggered by the incoming 240c/s square wave fed through capacitors C501, C502 and diodes MR501, MR502. When VT501 is conducting, its collector is at 0V and the base of VT502, which is supplied from the junction of potential divider R503, R505, is negative. VT502 is therefore cut off and its collector potential is almost +11V so that the current in R506 is sufficient to maintain conduction in VT501. This is the stable state of the circuit.

The incoming 240c/s square wave at pin U is differentiated by capacitor C501 and applied to the base of VT501 through diode MR501.The potentials at the collector and base of VT501 are almost the same (0V) and diode MR501 is therefore biased so that it will conduct the differentiated incoming pulse when it is negative going but will reject the positive going pulse. The negative going pulse cannot reach the base of VT502 because the diode MR502 is biased through resistor R508 by the +11V potential on the collector of VT502. Thus the negative going pulse cuts off VT501 and switches VT502 over to the conducting state. The next incoming negative going pulse is conducted by MR502 and rejected by MR501 so that the circuit reverts

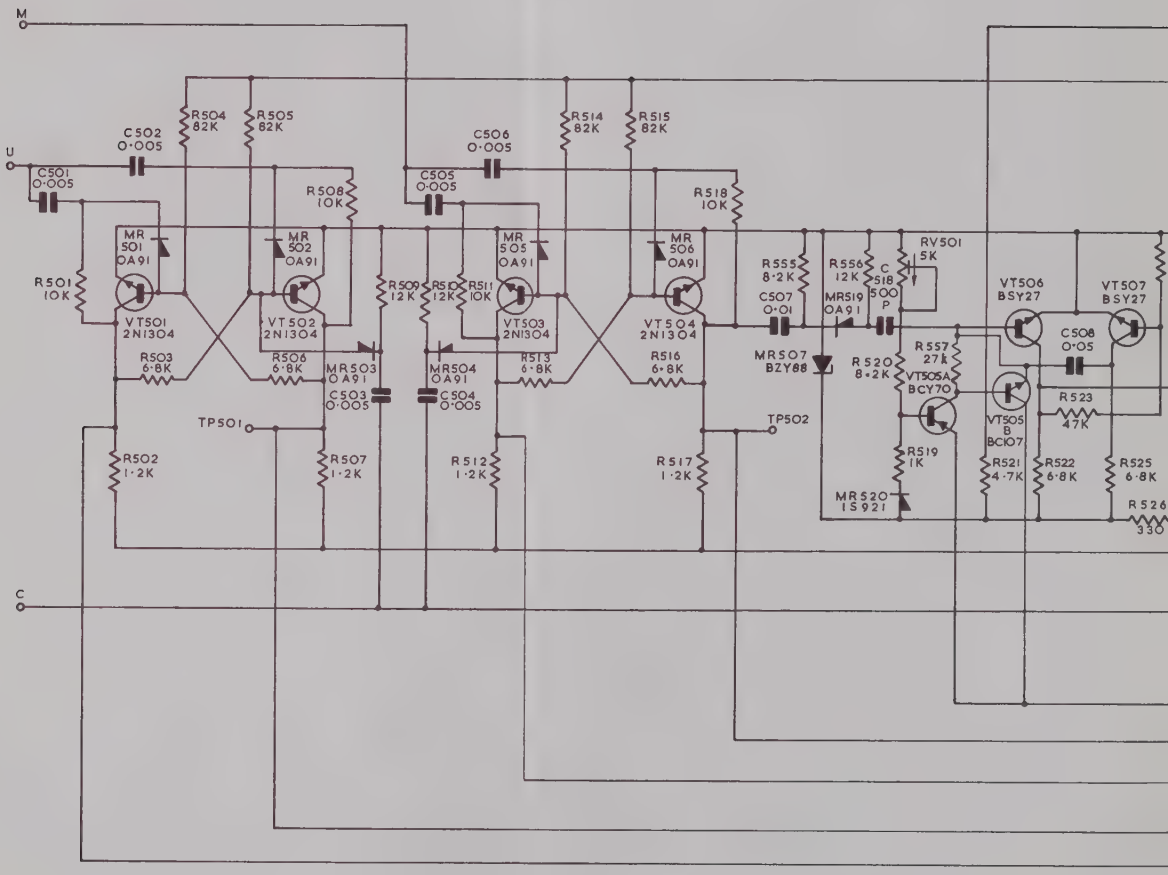
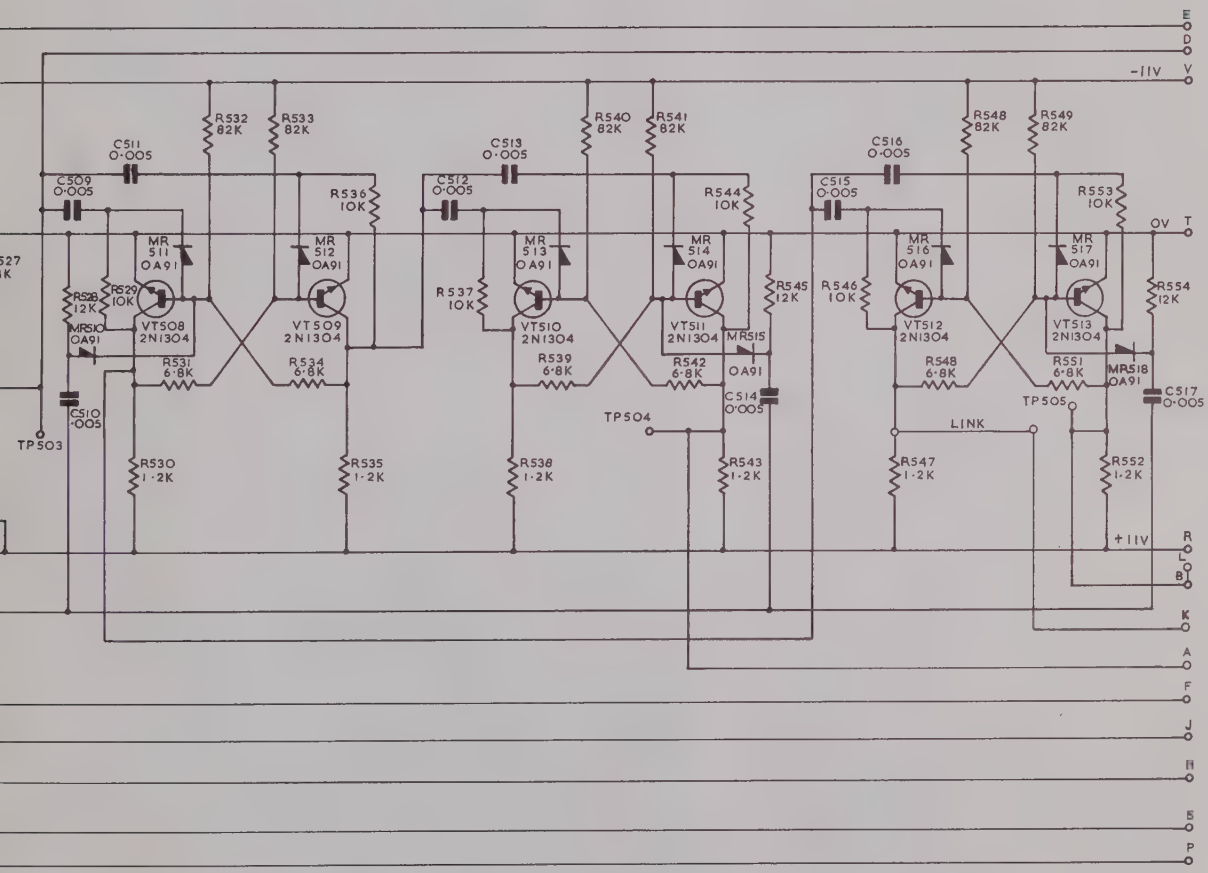


FIG. 22 BINARY (UNIT 5)
D/126051Q


E
D
-11V V
R532 82K
R533 82K
R540 82K
R541 82K
R548 82K
R549 82K
C511 0·005
C513 0·005
C516 0·005
C509 0·005
C512 0·005
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R536 10K
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C517 0·005
C510 ·005
C514 0·005
TP503
TP504
TP505
LINK
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R535 1·2K
R538 1·2K
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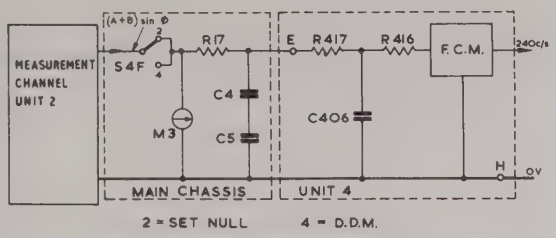

FIG. 21. OVERALL PHASE FEEDBACK LOOP.

the starter pulses were injected continuously into the f.c.m., its 240c/s output would be phase modulated by the 30c/s starter pulses and the 120c/s reference signal derived from these pulses would produce a spurious 30c/s signal in the 120c/s phase sensitive detector P1.

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Under initial conditions, before C412 has been charged and VT416 cut off, the 30c/s pulses at the base of VT417 are passed through the long tailed pair and capacitor C411 to the emitter of VT404 to initiate multivibrator operation. When the I.L.S. signal is applied to the system and unit 3 feeds a 150c/s sine wave to pin J of unit 4 plug, capacitor C412 charges and cuts off the long tailed pair so that the pulses at the collector of VT416 die away thus removing the multivibrator starting signal.

Binary unit 5 (figs. 22 to 24 and system diagram)

The input to the binary unit from the reference generator is the 240c/s (90c/s + 150c/s) square wave from the reference generator. The outputs required from the unit are:

1 Two quadrature 120c/s square waves locked in phase to the input.
2 Two quadrature 30c/s square waves locked in phase to the 120c/s reference, but with provision for manual adjustment of the phase of their common source.

The quadrature 120c/s references are produced from the antiphase 240c/s signals from the reference generator by division in binary circuits VT501, VT502 (B1) and VT503, VT504 (B2) in unit 5 (see fig. 22). The outputs from the collectors of the transistors are fed to pins P, S and H, J of unit 5 to provide the push pull switching operation required by the 120c/s phase sensitive detector P1.

The output from VT504 collector is passed through the phase shifter circuit comprising transistors VT506, VT507 and their associated components to binary divider VT508, VT509 (B3), which provides antiphase 60c/s signals at the collectors of the transistors. These 60c/s signals are divided in binary circuits VT510, VT511 (B4) and VT512, VT513 (B5). The quadrature, single drive signals required for switching the 30c/s phase sensitive detectors P2, P3 are taken from the collectors of VT511, VT513 through pins A and B of unit 5 plug.

The phase shift circuit incorporated in the unit compensates for the phase discrepancies introduced by production of the 30c/s signals from the 120c/s signal. The negative going sync pulses from unit 6, see p.37 are fed to each binary unit through pin C of unit 5.

Binary circuits (fig. 22)

The five binary circuits included in unit 5 are identical so that it is sufficient to describe one of them, for example, VT501, VT502.

VT501, VT502 are switching transistors triggered by the incoming 240c/s square wave fed through capacitors C501, C502 and diodes MR501, MR502. When VT501 is conducting, its collector is at 0V and the base of VT502, which is supplied from the junction of potential divider R503, R505, is negative. VT502 is therefore cut off and its collector potential is almost +11V so that the current in R506 is sufficient to maintain conduction in VT501. This is the stable state of the circuit.

The incoming 240c/s square wave at pin U is differentiated by capacitor C501 and applied to the base of VT501 through diode MR501.The potentials at the collector and base of VT501 are almost the same (0V) and diode MR501 is therefore biased so that it will conduct the differentiated incoming pulse when it is negative going but will reject the positive going pulse. The negative going pulse cannot reach the base of VT502 because the diode MR502 is biased through resistor R508 by the +11V potential on the collector of VT502. Thus the negative going pulse cuts off VT501 and switches VT502 over to the conducting state. The next incoming negative going pulse is conducted by MR502 and rejected by MR501 so that the circuit reverts

to its original state with VT501 conducting and VT502 cut off.

The signal from the sync pulse unit 6 is applied through pin C of unit 5 plug, capacitor C503 and diode MR503 to the base of VT502. If VT502 is conducting at the time the sync pulse is applied to its base but should be cut off, the sync pulse switches the transistor to its correct cut off state. Fig. 23 shows the 240c/s, antiphase, square wave inputs to the binary circuit and the quadrature 120c/s waveforms provided at the outputs of the first two binary circuits.

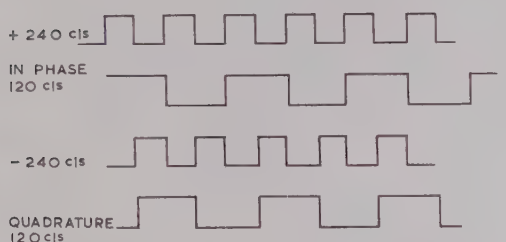


FIG. 23 WAVEFORMS OF 240 c/s AND 120 c/s SIGNALS

Phase shift circuit (fig. 24)

The phase shift circuit provides a variable pulse delay to the incoming signal from the collector of VT504. The circuit is operated from a separate 8.2V line, zener diode MR507 and diodes MR508, MR509 providing voltage stabilisation and temperature compensation. The delay is provided by the monostable circuit formed by transistors VT506, VT507 in conjunction with the variable current charging circuit provided for the timing capacitor C508 by transistors VT505a and VT505b.

In the absence of a pulse at the base of VT506, the potentials at the bases of the transistors forming the monostable circuit are such that VT506 conducts and VT507 is cut off. A negative pulse applied to the base of VT506 from the collector of VT504 through differentiating circuit C507, R555, diode MR519 and pulse shaping circuit R556, C518 cuts the transistor off. The potential at the junction of R523, R527 then biases VT507 positively and the transistor conducts. C508 charges through VT505 and eventually the base of VT506 becomes more positive than its emitter and the monostable circuit changes over to the state in which VT506 conducts and VT507 is cut off. The current in resistor R524 is virtually constant and ensures a sufficient bias on VT507 to maintain the transistor in the cut off state at the appropriate periods in the cycle.

The bias on VT505 is taken from the separately stabilised 8.2V supply through R519, R520 and preset control RV501. Resistor R521 and the Set Null control RV7 form the emitter resistor of VT505. The charging time of C508 is inversely proportional to the current in VT505 and the current through the transistor is inversely proportional to the value of its emitter resistor. Thus the time delay is directly proportional to the value of the emitter resistor and there is a linear relation between the rotation of the Set Null control RV7 and the phase shift obtained.

The output of the phase shifter is fed from the collector of VT506 to the next binary circuit VT508, VT509 and to test point TP8 and terminal D of the unit plug.

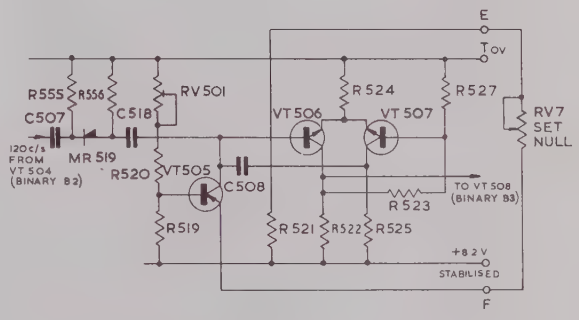


FIG. 24 PHASE SHIFT CIRCUIT IN UNIT 5.

Sync pulse generator unit 6 (figs. 25, 26 and system diagram)

Unit 6 is the printed circuit board comprising:

1 A comparator and pulse former circuit VT601 to VT605. The circuit produces one or two negative going pulses per 30 c/s period, depending on the phase of the received I.L.S. Signal. The input signal on pin N feeds from the summing amplifier of unit 3.

2 A paralyser circuit VT606 to VT608. The two pulses per 30c/s period are fed to the circuit, which passes only one of them to the next stage.

3 A switched delay circuit VT609, VT610 delays the pulses from the paralyser circuit by an amount which ensures that the synchronising pulse operates at the correct time. Transistor VT611 and its associated components shape the synchronising pulse fed to the binary circuits and the multivibrator starter circuit in unit 4 through pin V of the unit plug.

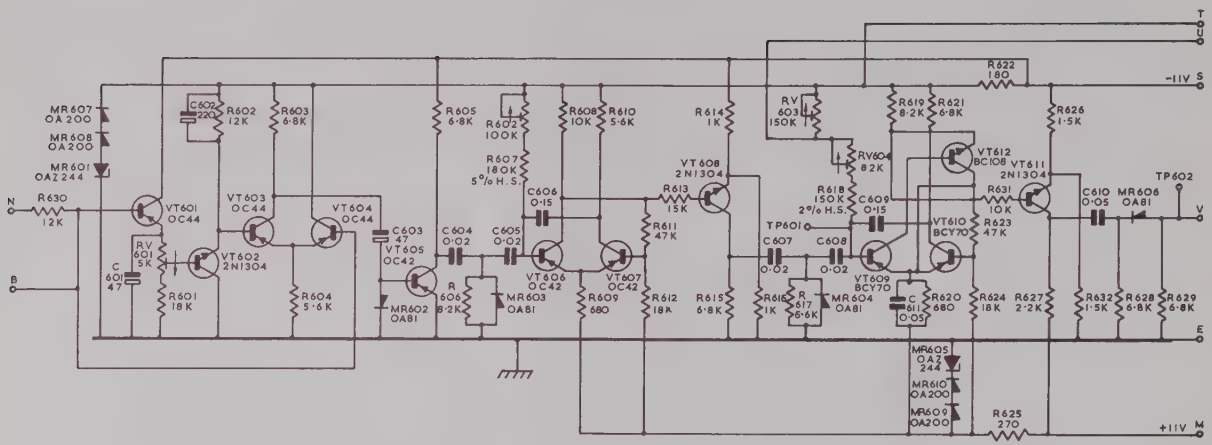


FIG. 25 SYNC PULSE GENERATOR UNIT 6
D12606/S

Comparator and pulse former (fig. 25)

The signal from the summing amplifier unit 3 is fed to pin N of unit 6 plug. A waveform is produced which has only one peak per 30c/s interval for a normal I.L.S. input see fig. 28.18.

VT601, VT602 are peak detector transistors, VT602 being of the npn type. The mixed waveform from resistor R630 is applied to the base of VT601 and a signal proportional to the peak of the incoming waveform is produced at the emitter of VT602. The delay time constants produced by capacitors C601 and C602 are very long compared with the 30c/s time interval. Preset control RV601 is set to produce a d.c. at the emitter of VT602 which is just below the value of the peak amplitude of the incoming waveform.

Transistors VT603, VT604 are connected as a long tailed pair. The input to the base of VT603 is taken from the emitter of VT602 and the base of VT604 is connected to the base of VT601. Whilst VT604 base is held positive to the base of VT603 by the incoming waveform, the transistor is cut off and VT603 conducts. At negative peaks of the incoming waveform, VT604 base is more negative than VT603 base and VT604 conducts and cuts off VT603. Thus negative going pulses are produced at the collector of VT603 which are fed through capacitor C603 to the pulse forming stage VT605. Diode MR602 operates as a d.c. restorer. The method of using the d.c. from the peak detected waveform for comparison in the long tailed pair instead of a fixed d.c. ensures that variations of input level of the I.L.S. waveform, from which the a.f. input to the unit is derived, do not affect the operation of the comparator.

The negative going pulses at the collector of VT603 are amplified by VT605 and passed through the differentiating and clipping circuit C604, R606, MR603 and C605 to provide positive going pulses at the base VT606.

Paralyser circuit (fig. 25)

The paralyser VT606 to VT608 is a monostable circuit with collector to base coupling. The charging current for the circuit is supplied through resistor chain R607, RV602 and timing capacitor C606. Preset control RV602 is set up to give a time delay of approximately four fifths of the 30c/s period. Thus, if two pulses per 30c/s period come from the

comparator and pulse former circuit, the paralyser circuit will trigger on one of them but not on the other, i.e. the circuit will be in a paralysed state for the second pulse.

In the absence of an incoming positive pulse, the base of VT606 is more negative than the base of VT607 and VT606 conducts whilst VT606 is cut off. A positive pulse at the base of VT606 switches the circuit over to VT606 cut off and VT607 conducting thus producing a negative going pulse at the collector of VT606. The pulse is applied to the base of npn amplifier VT608 and triggers it from the conducting to the non-conducting state so producting a positive going pulse at the collector of VT608.

Switched delay circuit (fig. 26)

The switched delay circuit comprising the collector to base coupled monostable circuit VT609, VT610 and the amplifier VT611 is practically identical with the paralyser circuit. However, the delay circuit has two different delay times which are selected by the Reset Phase switch S6. When switch S6 is depressed, RV603 is short circuited thus reducing the time delay.
The output from the delay circuit is a negative going pulse at the collector of VT611 when a positive going pulse is formed at the collector of VT605. The output is fed to the binary unit 5 through the differentiating circuit C610, R628 and diode MR606. The diode ensures that the output consists only of negative pulses. The signal at pin V is also applied to the multivibrator circuit in the reference generator.

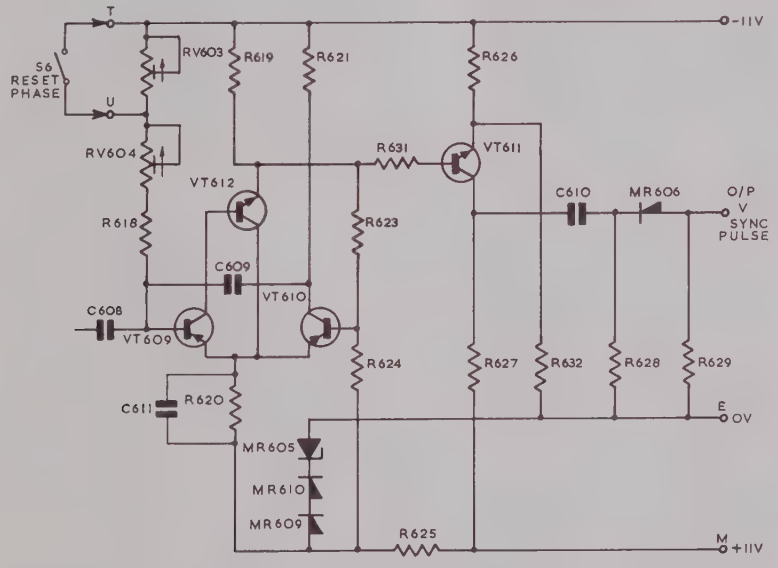


FIG.26 SWITCHED DELAY CIRCUIT UNIT 6

Offset D.D.M. board (fig. 27)

The Offset D.D.M. circuit is mounted on a printed circuit board comprising:

1 A low pass filter RV1001, R1004 and C1002 with a current driver stage VT1001 and VT1002 at its output, C1001 providing feedback across the stage. The square wave input from the binary unit B5 is filtered producing a 30c/s sine wave which is applied to a switched attenuation network.

2 Two attenuators in series are calibrated in percentage D.D.M., a coarse attenuator S1001 providing increments in multiples of ten up to 30 and a fine attenuator S1002 multiples of one up to 10. Both attenuator switch outputs are fed to the summing amplifier via current drive stages VT1003, VT1004 and VT1005, VT1006. transformer coupled to the signal path between units 1 and 2 when the offset D.D.M. is selected. Inputs from the attenuators are a.c. coupled to VT1007 through C1004. VT1008 is an emitter follower driving the mixing transformer T1001 and decoupling capacitor. C1006 is connected across load resistor R1031.

Should the signal present at the input to unit 2 have a predominance of 150c/s tone, the output connections to the mixing transformer T1001 can be reversed to compensate for this condition. Changing the connections to T1001 is achieved by selecting the 150c/s position on the 90/150 switch on the front panel. When the offset facility is selected on the Normal/Offset switch, the 30c/s output of the offset D.D.M. board backs off the 30c/s content of the signal to unit 2 allowing selection of a more sensitive D.D.M. range.

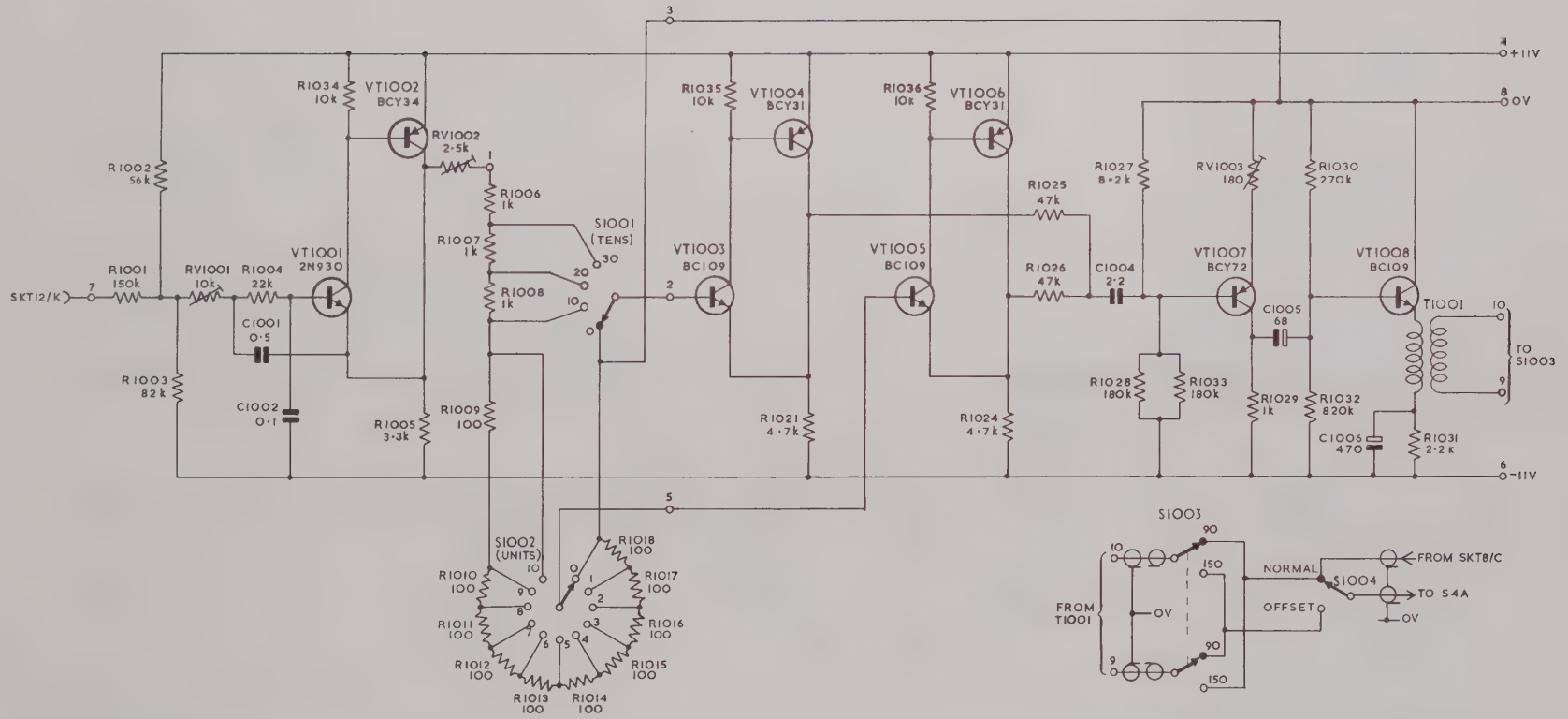


FIG.27 OFFSET D.D.M (D16133)

MAINTENANCE

Warning: The N100 requires precision test equipment and skilled personnel for maintenance and calibration of the instrument. Any adjustments to the receiver are liable to upset the modulation depth calibration, especially at extremes of the frequency bands. The information and instructions given below are only for use in circumstances in which it is impossible to return the instrument to the manufacturer for maintenance.

A fault guide is given which should be followed to locate the area of a fault. Signal frequencies and values at test points provided at the rear of the instrument are given in the guide. Waveform information and d.c. levels at critical points are given in the maintenance data provided to assist in detailed fault finding.

The equipment required for calibration is:

(1) Precision a.f. voltmeter (average reading), to read 1V r.m.s. ±0.5 per cent.

(2) Precision d.c. voltmeter with input impedance greater than 100 KΩ to read 100 mV ±0.5%.

(3) I.L.S. tone generator.

a R.F. with modulation depth adjustable from 16% to 24% each tone (zero d.d.m.) on localiser frequencies and 32% to 48% each tone on glide path frequencies.

b A.F. with tone frequency accurate to ±0.2% and relative phase of tones adjustable over whole range.

(4) Modulation depth indicator, accuracy ±1% of *actual modulation depth reading.*

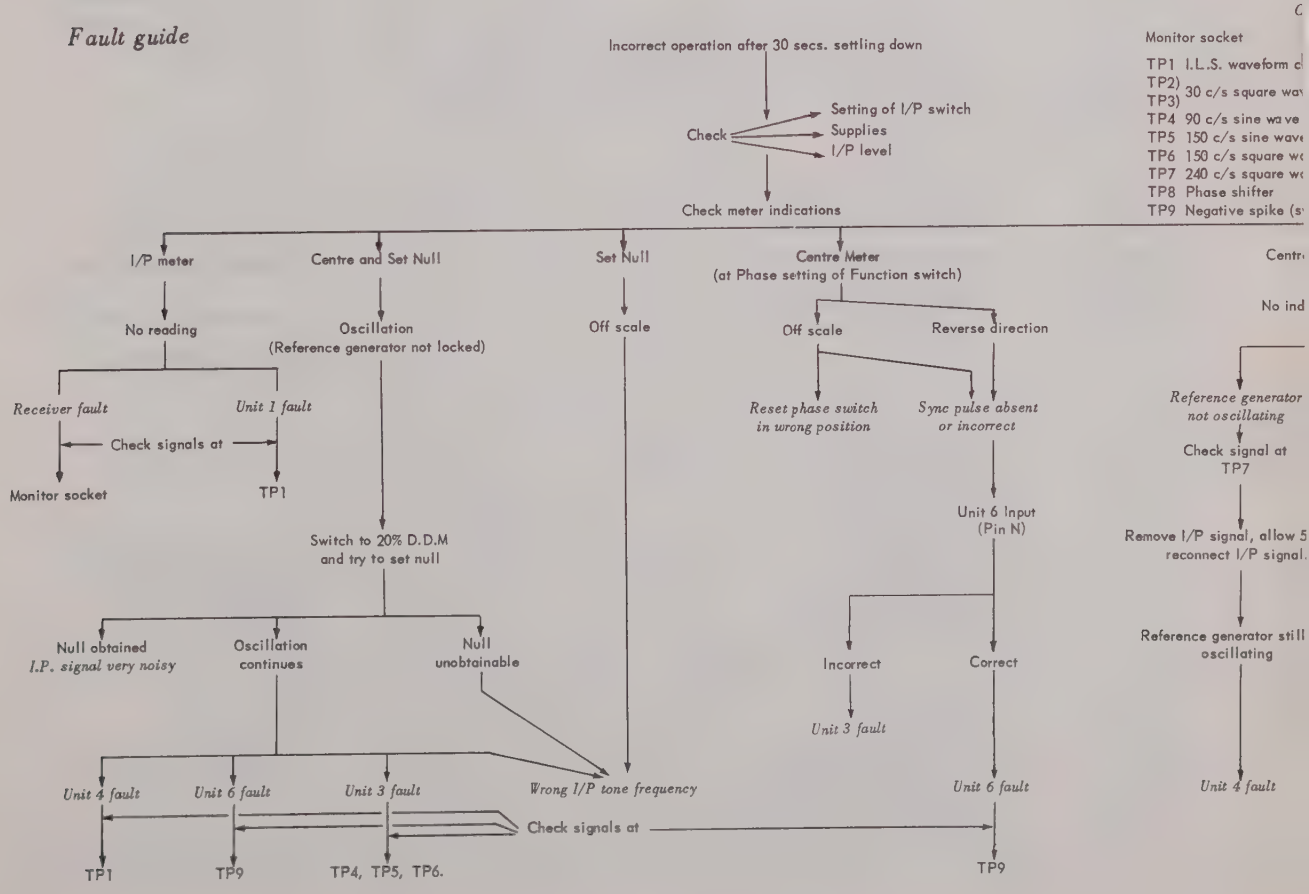
(5) D.C. oscilloscope, 100mV/cm sensitivity.

Location of Fault Areas

If the instrument does not function correctly after following the operating instructions given in pp. 8 to 9, the checks detailed below should be made.

1 Follow the fault guide to locate the area of the fault. (The Monitor socket is on the front panel, test points are under the flap at the rear of the instrument).

Fault guide



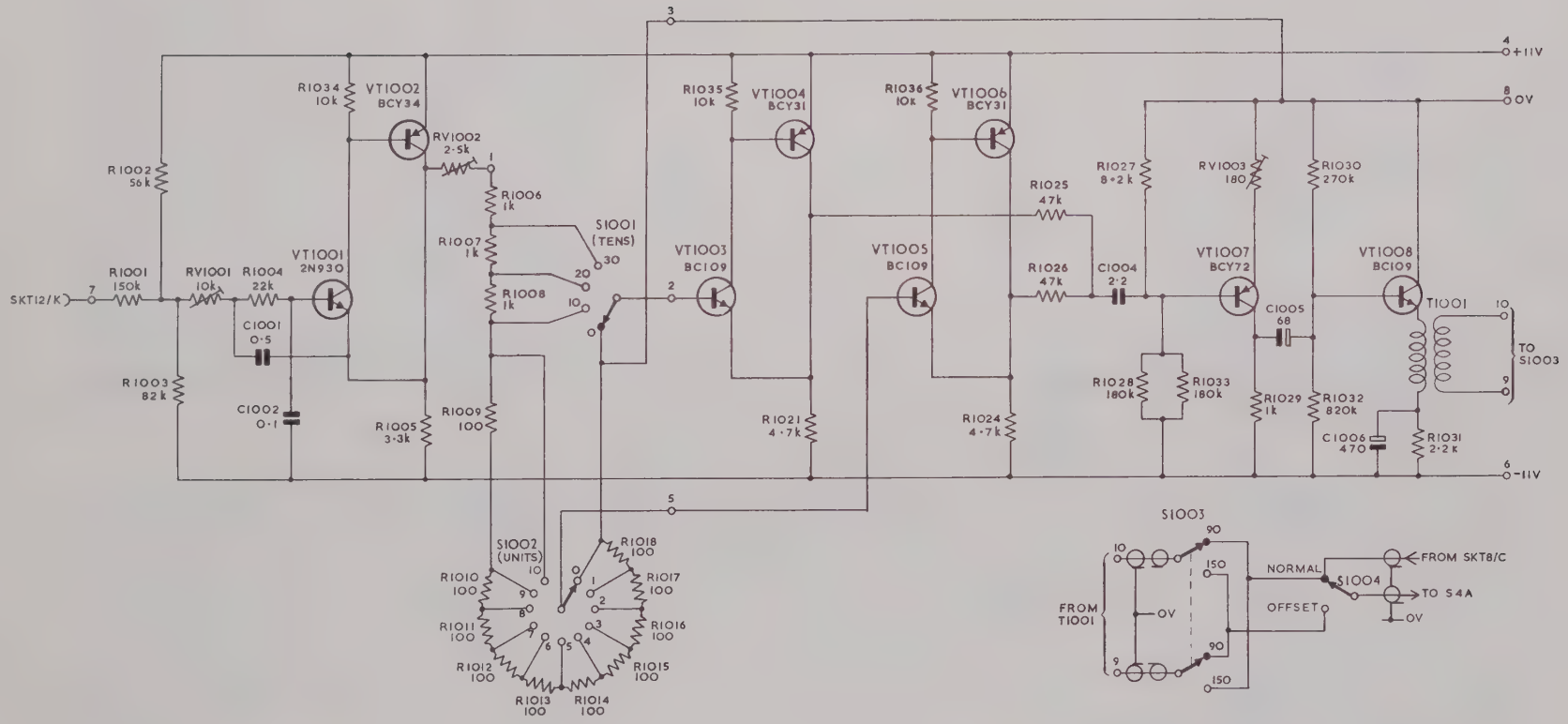


FIG.27 OFFSET D.D.M (D16133)

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a R.F. with modulation depth adjustable from 16% to 24% each tone (zero d.d.m.) on localiser frequencies and 32% to 48% each tone on glide path frequencies.

b A.F. with tone frequency accurate to ±0.2% and relative phase of tones adjustable over whole range.

(4) Modulation depth indicator, accuracy ±1% of *actual modulation depth reading.*

(5) D.C. oscilloscope, 100mV/cm sensitivity.

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If the instrument does not function correctly after following the operating instructions given in pp. 8 to 9, the checks detailed below should be made.

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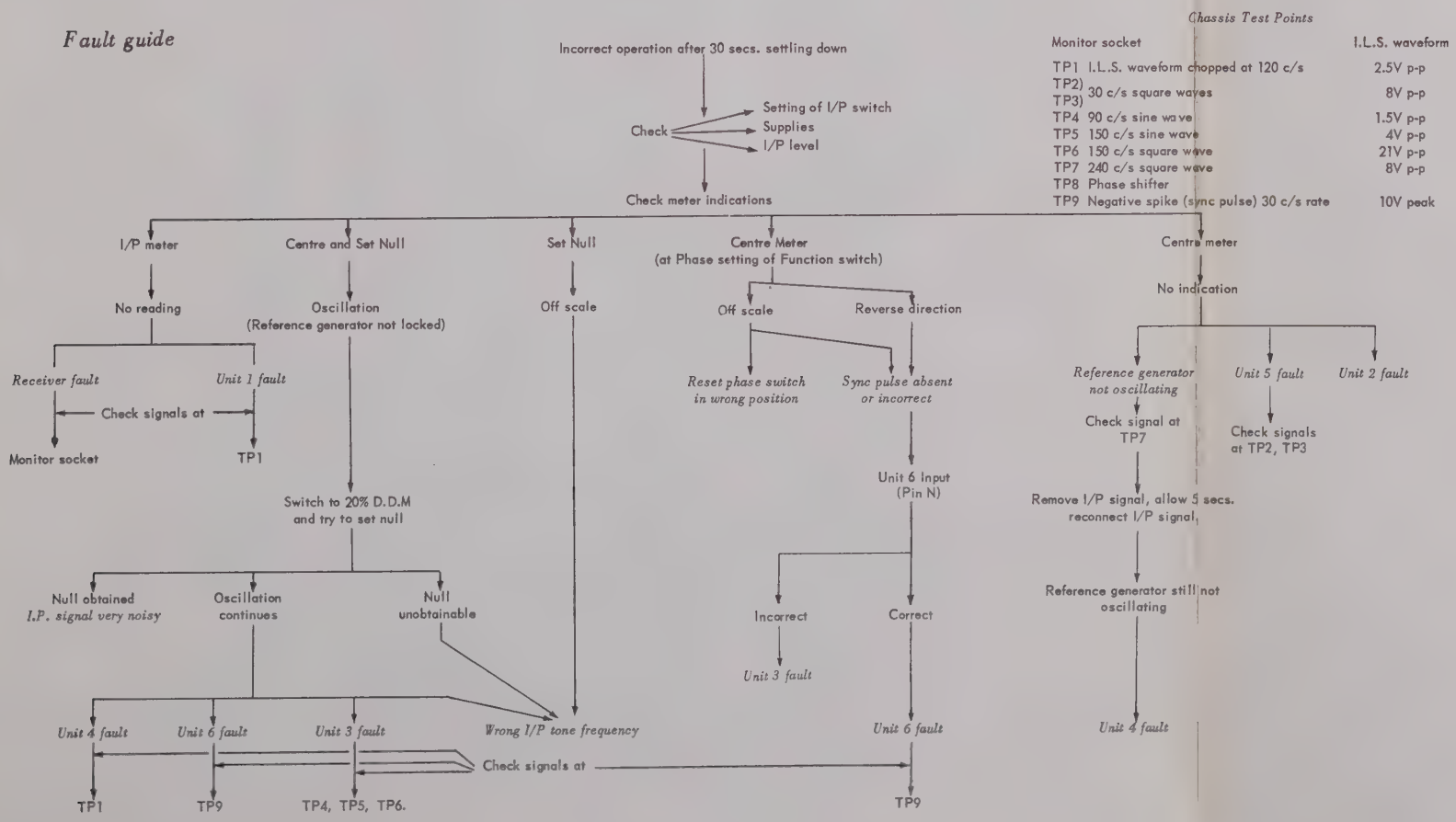
Fault guide



Chassis Test Points

Monitor socket		I.L.S. waveform
TP1	I.L.S. waveform chopped at 120 c/s	2.5V p-p
TP2) TP3)	30 c/s square waves	8V p-p
TP4	90 c/s sine wave	1.5V p-p
TP5	150 c/s sine wave	4V p-p
TP6	150 c/s square wave	21V p-p
TP7	240 c/s square wave	8V p-p
TP8	Phase shifter	
TP9	Negative spike (sync pulse) 30 c/s rate	10V peak

Location of Faults in Units

2 Loosen the eight fixing screws holding the instrument in its case and withdraw the chassis.
3 Switch on the N100 and set up as operating instructions.

Receiver (see warning p. 41)

With 1mV p.d. at the aerial modulated by each tone at 20 per cent and the N100 Inputs switch set to Loc, GP1 or GP2, the receiver detector output at PL702/11 should be between 2.8V and 3.2V d.c. and approximately 2.2V peak to peak of I.L.S. waveform. These figures should hold within 10 per cent over an input range of 100μV to 50mV. Adjustments are made by:
RV702 for a.g.c. working point
RV701 for localiser r.f. head a.g.c. takeover point
RV703 for glide path r.f. head a.g.c. takeover point.

Adjustments to the local oscillator are made by:
L703 for localiser local oscillator, 143Mc/s, (Inputs switch set to Loc)
C761 for glide path local oscillator, 297 Mc/s for GP1, 301 Mc/s for GP2 (Inputs switch set to GP1 or GP2)
RV704 for glide path local oscillator (Inputs switch set to GP1).

Units 1 to 6 and power supplies

4 Follow the maintenance data to locate faults in units 1 to 6, the power supply and stabiliser units.

aintenance data for all units apart from receiver

Unit	Test Point	Waveform	A.C. p-p	D.C. level (where significant)	Waveform Diagram (p.44 & p.45)	Remarks
Unit 1 Buffer Amplifier	I/P (Input) Pin S	I.L.S. Waveform	2.2V	+3V	–	
	TP101	I.L.S. Waveform	5V	0V	–	
	TP102, 103	120 c/s square wave	9V	–	–	
	TP104	I.L.S. waveform chopped at 120c/s (changes with Function switch setting)	2.5V	0V	1 Phase or M.D. 2 Set Null or DDM	If chopping is not synchronous as in diagram then Reference Generator is not locked
	O/P (Output) Pin C	Smoothed version of TP104	up to 2.5V	0V	3 Phase or M.D. 4 Set Null or, DDM	
Unit 2 30c/s Amplifier Phase Sensitive Detectors 2% DDM range 2% DDM signal (or 1db tone ratio)	I/P Pin B	Very small signal - virtual earth	–	−0.3V	–	Gain of filters adjusted by RV201, RV203
	TP201	30c/s sine wave, slight ripple	55 mV	−5V to −7V	5	Phase adjusted by RV204
	TP202	30c/s sine wave	700 mV	−5V to −7V	–	
	TP203	30c/s sine wave	700 mV	−1V to +1V	–	
	Take from T201 Yellow	30c/s P.S.D. waveform	350 mV	0V	6	
	Take from T201 Green	30c/s P.S.D. waveform	700 mV	0V	7	
	Take from T201 White	30c/s P.S.D. waveform	170 mV	100mV	8	
	Take from T201 Orange	30c/s P.S.D. waveform	350 mV	100mV	9	
Unit 3 90 and 150c/s Filter and Squarer	I/P Pin A	I.L.S. waveform	5V	0V		
	TP301	90c/s sine wave with less than 10% 150c/s	1.5V	−4V to −6V	10	150c/s minimised by RV301
	TP302	150c/s sine wave with less than 2% 90c/s	2V (approx)	–		90c/s minimised by RV302
	TP303	150c/s sine wave (slight distortion)	4V	−3.5V to −5.5V	11	Amplitude adjusted to 4Vp-p by RV303
	Collector VT308	150c/s sine wave		−4.5V to −6.5V		
	Emitter VT314	150c/s square wave, fast rise time	10V			
	Emitter VT313	Multiar feedback spike 150c/s rate	4V		12	Absence of spike shows malfunction of Multiar
	IC301	90c/s square wave	1Vpk-pk			
	Pin V	90c/s sine wave	2Vpk-pk			Adjusted for slight phase advance on TP 301 by RV304
	Pin R	90/150c/s composite waveform	5Vpk-pk	+2V to +2.5V	18	
Unit 4 Reference Generator	I/P Pin A	90c/s sine wave from Unit 3	1.5V		10	
	I/P Pin C	150c/s square wave from Unit 3	20V			
	I/P Pin J	150c/s square wave from Unit 3	3.75V to 4.25V		11	
	I/P Pin V	Sync pulse from Unit 6				
	I/P Pin D	Set Null control wiper		−8V to +8V		
	Pin F	Internal zener stabilised supply		−7.6V to −8.8V		
	Pin P	Internal zener stabilised supply		+7.6V to +8.8V		
	TP401	240c/s square wave	21V			1:1 mark/space ratio adjusted by RV402 Frequency (coarse) adjusted by RV401
	Take from T401 Yellow	90c/s chopped at 240c/s	1.5V	0V	13	If chopping is not synchronous, as in
	Take from T402 Yellow	As T401 but chopped again at 150c/s	1.5V	0V	14	diagram, then Reference Generator is
	TP403	Decaying series of pulses when I/P signal is removed for 5 seconds, then restored.			15	not locked. Maximum decay *to zero* 5 seconds
Unit 5 Binary Unit	I/P Pins M, U	240c/s square wave from Unit 4	10V			
	I/P Pin C	Sync Pulse, 30c/s rate	10V			
	R526, R525 Junction	Internal zener stabilised supply		+7.6V to +8.8V		
	TP501	120c/s square wave	10V			Waveform *positive* at sync pulse
	TP502	120c/s square wave, quadrature to that at TP501	10V			Waveform *negative* at sync pulse
	Base VT506	Triangular wave varied by Phase control	8V		16	
	TP503	Square wave, m/s ratio varied by Phase control.	6V		17	
	TP504	30c/s square wave	8V			Waveform *positive* at sync pulse
	TP505	30c/s square wave quadrature phase to TP504	8V			Waveform *positive* at sync pulse

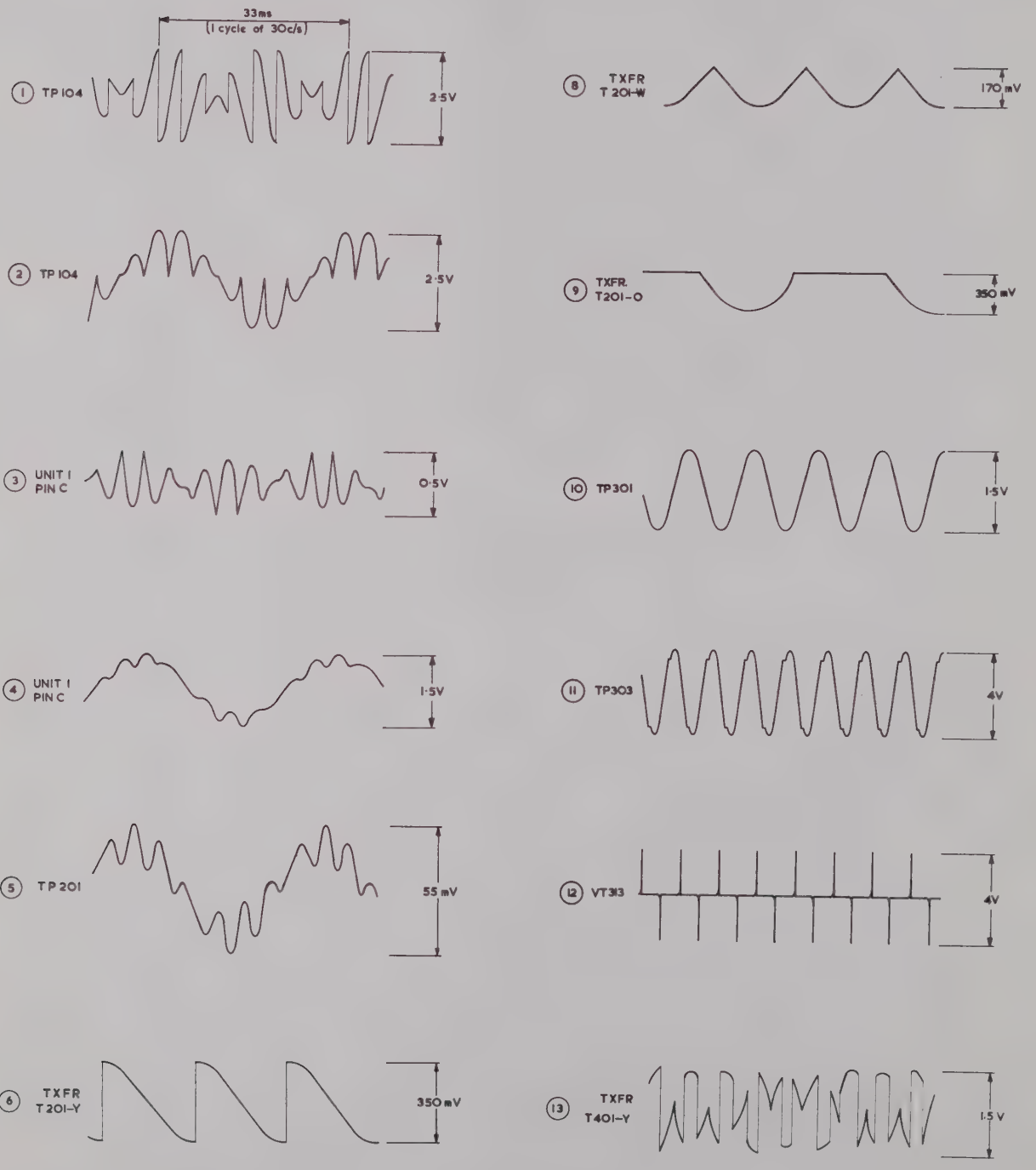
Maintenance data for all units apart from receiver (contd.)

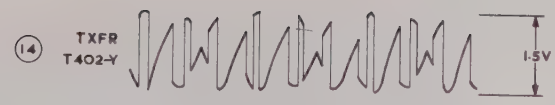
Unit	Test Point	Waveform	A.C. p-p	D.C. level (where significant)	Waveform Diagram (p.44 & p.45)	Remarks
Unit 6 Sync Pulse Generator	I/P Pin N	90/150c/s composite waveform	5V		18	This consists of 90c/s sine wave mixed with 150c/s square wave in unit 3.
	Collector VT603	Small negative pips, 30c/s rate	200 mV (approx)		19	Pips occur at 60c/s rate when I/P I.L.S. waveform (i.e. pin N) is abnormal phase
	Collector VT605	Narrow positive pulses	10V			Pulse width adjusted to 1.0m secs to 1.5m secs at mid-height by RV601
	Collector VT606	5:1 m/s ratio square wave 30c/s rate (paralyser)	13V		20	m/s ratio adjusted by RV602
	TP601	Triangular waveform, varied by Reset Phase switch (variable delay)	15V		21	Position of sync pulse with respect to other waveform adjusted by RV603, RV604. *See Note at end of data*
	Collector VT611	Square wave version of TP601	12V		22	
	TP602	Negative pulse, 30c/s rate	10V		23	
	R625, R620 Junction	Internal zener stabilised supply		+7.6V to +8.8V		
	R622, R621 Junction	Internal zener stabilised supply		−7.6V to −8.8V		
Power Supply Unit	Taken from each secondary tap to centre	50c/s	14.5V to 15.5V r.m.s.			
	Pin 6	d.c.	less than 1.5V	+15V to +17V		
	Pin 7	d.c.	less than 1.5V	−15V to −17V		
Stabiliser Unit	Pin 14	Main negative stabilised supply	less than 10mV	−11.0V		Supply voltage adjusted by RV803 Ripple minimised by RV801
	Pin 15	Receiver negative supply	less than 1mV	−10.6V		
	Pin 2	Main positive stabilised supply	less than 10mV	+11.0V		Supply voltage adjusted by RV804 Ripple minimised by RV802
	Pin 13	Receiver positive supply	less than 1mV	+10.6V		

Note: Position of the sync pulse is critical and is normally carried out at the factory by comparison, with a standard unit. Any adjustment is likely to be small, and should be such that, with the Function switch set to Phase and with a normal phase I.L.S. signal, the rotation of the Phase control from end to end in a positive direction (i.e. towards +40°) causes a meter indication moving from left to right.

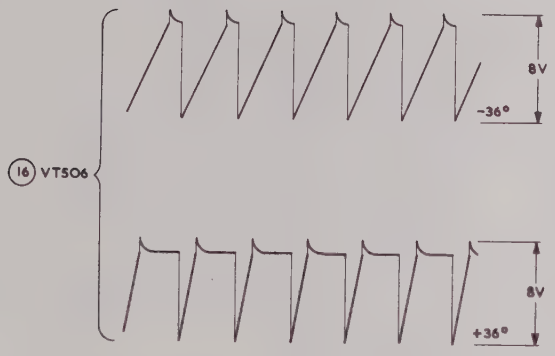
FIG. 28, PT.1, WAVEFORM DIAGRAMS

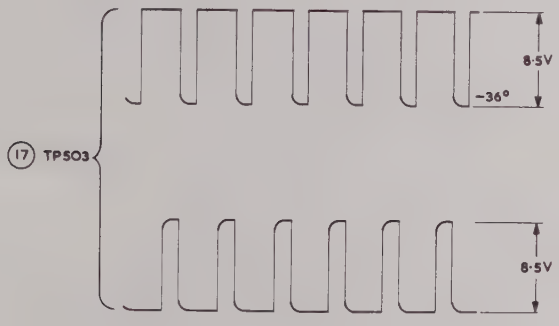
TIME BASE IS CONSTANT FOR ALL DIAGRAMS

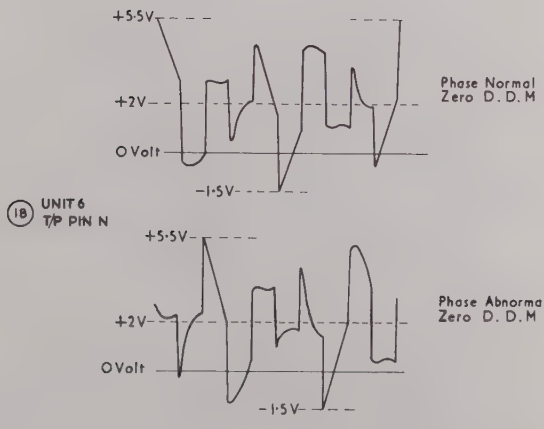


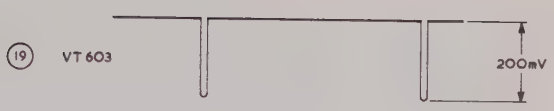

14
TXFR
T402-Y
1·5V

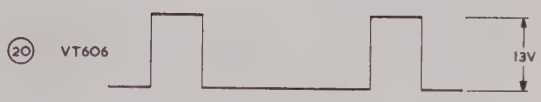
15
TP 403


16
VT506
8V
-36°
8V
+36°


17
TP503
8·5V
-36°
8·5V

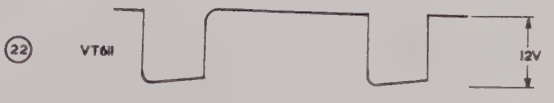

18
UNIT 6
T/P PIN N
+5·5V
+2V
0 Volt
-1·5V
Phase Normal
Zero D. D. M
+5·5V
+2V
0 Volt
-1·5V
Phase Abnormal
Zero D. D. M

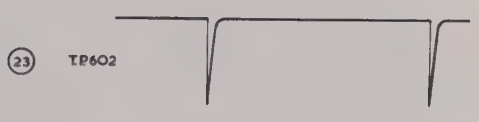

19
VT 603
200mV


20
VT606
13V

21a
T.P601
15V

21b
RESET
PHASE
15V


22
VT611
12V


23
T.P602

Calibration

Zero d.d.m.

No provision is made for recalibration of zero d.d.m. Any discrepancy greater than that given in the specification indicates either a malfunction or incorrect setting up.

D.D.M. meter

5 Connect the a.f. voltmeter between test point TP101 on unit 1 and ground. Connect the d.c. voltmeter across the Monitor D.D.M. sockets at the rear of the main chassis.

6 Feed an a.f. signal at zero D.D.M. from the I.L.S. tone generator into the A.F. Inputs socket on the front panel with Input switch set to A.F.

7 Set the Supplies/Level switch to Level and adjust the A.F. Set Level control for a 1.00V r.m.s. reading on the voltmeter. Level meter M1 should indicate close to datum line.

8 With the 1 volt a.f. level unchanged set up the instrument to read d.d.m. on the 2% range as operating instructions 16 to 17 p. 9

9 Set the Function switch to 2% D.D.M.

10 Adjust the d.d.m. of the input signal to give zero reading on the d.c. voltmeter connected to the Monitor D.D.M. sockets.

11 Switch in a 2% offset d.d.m.

12 Check that the centre meter on the front panel shows full scale deflection and the d.c. voltmeter at the Monitor D.D.M. sockets indicates 100mV ±1mV. Repeat using a −2% offset.
If necessary adjust the gain controls RV201 and RV203 in unit 2 by equal amounts to obtain these indications in both polarities.
Note: Alternatively a 1db d.d.m, i.e. 2.22%, should give just over full scale deflection on the centre meter and a reading of 111mV on the d.c. voltmeter connected to the Monitor D.D.M. sockets.

13 Supply the internal calibration signal to the centre meter on the instrument front panel by setting the Function switch to Mod Depth and depressing the Calibrate switch.

14 Check that the centre meter reads exactly zero with the a.f. voltmeter, connected between test point TP101 in unit 1 and ground, indicating 1.00V r.m.s. If zero meter reading is not obtained, apply an a.f. signal adjusted to obtain a zero D.D.M. reading, with function switch set to 0.2% D.D.M. range with A.F. level set to obtain 1.00V r.m.s. indication at TP1001, operation of the CAL switch should produce a reading of exactly −0.2% D.D.M. (−100mV d.c. at monitor sockets). If necessary, adjust RV101 (Unit 1) to obtain this reading. Return function switch to MOD DEPTH and depress CAL switch. Centre meter should indicate zero for 1V r.m.s. indication at TP101. If necessary, adjust preset control RV9, located at the rear of the centre meter, to obtain the readings specified.

Phase control scale

15 Feed an a.f. signal from the I.L.S. tone generator to the A.F. Input socket of the N100.
Note: Tone frequencies must be accurate to ±0.2 per cent.

16 Connect the oscilloscope to the Monitor socket on the N100 front panel.

17 Observe the I.L.S. waveform at the Monitor socket and adjust the relative phase until the abnormal phase condition is obtained, see fig. 28a, with peaks B-B exactly level, the N100 phase control set at the +40 end of the scale and centre meter indicating approximately zero.

18 Set the N100 Phase Control at exactly +36 and adjust preset control RV102 of unit 1 to obtain the conditions of calibration instruction 17 above with the N100 centre meter reading exactly zero.

19 Depress the N100 Reset Phase switch and turn the Phase control to the −40 end of the scale until the conditions of calibration instruction 17 are obtained.

20 Set the N100 Phase control to exactly −36 and adjust preset control RV501 of unit 5 to obtain the conditions of calibration instruction 17 with the N100 centre meter reading exactly zero.

21 Lift the Reset Phase switch and readjust preset control RV102 of unit 1, with the Phase control in the +36 position, to obtain the conditions of calibration instruction 18.

22 Repeat calibration instructions 18 to 21 until the conditions remain correct.

23 Observe the I.L.S. waveform at the Monitor socket and adjust the relative phase to normal phase condition, see fig. 28b, with peaks A-A exactly level and check that the Phase control reading is zero.
If necessary, make slight adjustment of preset control RV102 of unit 1 to obtain this condition.

Modulation Depth

24 Adjust the I.L.S. input signal frequency to 110 Mc/s, 20 per cent mean modulation depth, 10mV.

25 Turn the N100 Input switch to Loc, set up the instrument and read modulation depth as operating instructions 16 to 18, and 10, p. 9 taking special care over the setting of the Set Null and Phase controls.

26 If necessary, correct the Modulation Depth Control reading for zero meter indication by adjusting preset control RV1 on the sub-panel behind the front panel and adjacent to the input sockets.

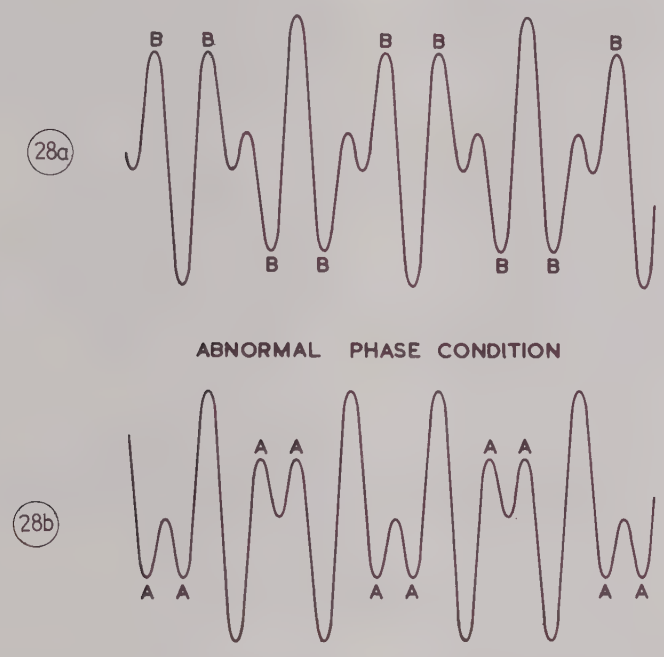
27 Check the Modulation Depth control reading with I.L.S. input signals at 16 per cent and 24 per cent modulation depth. If the discrepancy is greater than 0.2 per cent on either reading,

a full recalibration must be made using RV1 to calibrate at 16 per cent and RV3 at 24 per cent, with a final check at 20 per cent.

28 Set the Inputs switch to GP1 and calibrate the Modulation Depth control at 40 per cent mean modulation depth of the I.L.S. input signal. Use preset control RV8 to correct calibration.

29 Set the Inputs switch to GP2 and proceed as in calibration instruction 28.

FIG 28,PT.2 I.L.S WAVEFORMS OF COMBINED TONES



APPENDIX I

Vector representation of the composite a.f. signal (Fig. 4)

The composite a.f. signal, comprising the 90c/s and 150c/s tones of unequal amplitudes A and B respectively, can be represented as two vectors A and B differing arbitrarily in phase and rotating at a frequency of 30c/s, i.e. [(150 – 90)/2], in opposite directions with respect to a stationary reference axis II', see fig. 4a. The position of axis II' corresponds to that of a vector of frequency equal to 120c/s, i.e. [(150 + 90)/2].

Fig. 4b shows two large vectors of equal length (A+B)/2 and two small vectors each of length (A–B)/2. The vectors rotate at 30c/s in opposition, the larger vectors about axis II' and the smaller vectors about axis QQ', which is at right angles to axis II'. When the small vectors are added vectorially to the large vectors, fig. 4b becomes identical with fig. 4a.

By taking the axis II' in fig. 4b as the phase reference of the two tones the combined signal may be written as:

$$F(t) = A\cos(\omega_c - \omega_m)t + B\cos(\omega_c + \omega_m)t$$

where $\omega_c = (\omega_{150} + \omega_{90})/2 = 2\pi \times 120$ rads/sec.

$\omega_m = (\omega_{150} - \omega_{90})/2 = 2\pi \times 30$ rads/sec.

Expanding the cosine terms and rearranging F(t) gives:

$$F_1(t) = (A+B)(\cos\omega_c t \cos\omega_m t) + (A-B)(\sin\omega_c t \sin\omega_m t) \quad \ldots\ldots\ldots\ldots 1$$

Thus the general case of the composite signal comprising two tones of unequal amplitude may be regarded as the sum of two suppressed carrier modulation systems having:

(1) a suppressed carrier $\cos\omega_c t$ modulated with $(A+B)\cos\omega_m t$.

(2) a suppressed carrier $\sin\omega_c t$ modulated with $(A-B)\sin\omega_m t$.

Both the carriers and modulation signals are therefore in phase quadrature.

APPENDIX 2

Operation of phase sensitive detector P1 (fig. 3)

2.1 Output of P1 operating on a quadrature 120c/s reference.

Suppose that, with switch SA turned to Set Null or D.D.M., P1 operates on a *quadrature* 120c/s reference having a phase error ϕ, i.e. $\sin(\omega_c t + \phi)$. A signal $F_1(t)$, p 47 is applied to P1 and its output can be found by multiplying $F_1(t)$ by $\sin(\omega_c t + \phi)$ and rejecting all components of twice the suppressed carrier frequency ω_c. The output will be a 30c/s signal proportional to:

$$F_2(t) = (A+B)\cos\omega_m t \sin\phi + (A-B)\sin\omega_m t\cos\phi \quad \ldots\ldots\ldots\ldots 2$$

$F_2(t)$ represents a signal with two components in quadrature, one along axis QQ', i.e. $(A-B)\sin\omega_m t\cos\phi$, and the other along axis II', i.e. $(A+B)\cos\omega_m t\sin\phi$. If there is no phase error in the 120c/s reference, $\phi = 0$ and the component along II' becomes zero leaving only the component along QQ', i.e.

$$F_3(t) = (A-B)\sin\omega_m t \quad \ldots\ldots\ldots\ldots\ldots\ldots 3$$

This is a 30c/s signal with amplitude variation along QQ' which is proportional to the difference in amplitude of the two tones, (A–B).

2.2 Output of P1 operating on an in phase 120c/s reference:

Suppose that, with switch SA set to Phase or Modulation Depth, P1 operates on an *in phase* 120c/s reference having a phase error ϕ. P1 then uses a reference signal $\cos(\omega_c t + \phi)$ and its output, when a signal $F_1(t)$ is applied, is found by multiplying $F_1(t)$ by $\cos(\omega_c t + \phi)$ and rejecting all components of twice the suppressed carrier frequency ω_c or changing ϕ to $(\phi + \pi/2)$ in $F_2(t)$. The output will be a 30c/s signal proportional to:

$$F_4(t) = (A+B)\cos\omega_m t\cos\phi - (A-B)\sin\omega_m t\sin\phi \quad \ldots\ldots\ldots\ldots 4$$

As in section 2.1, $F_4(t)$ represents a signal which has vector components along axes II' and QQ'. If there is no phase error in the 120c/s reference, $\phi = 0$ and the component along axis QQ' vanishes leaving only the component along axis II', i.e.

$$F_5(t) = (A+B)\cos\omega_m t \quad \ldots\ldots\ldots\ldots 5$$

This is a 30c/s signal with amplitude variation along II' which is proportional to the sum of the amplitudes of the two tones (A+B).

APPENDIX 3

Operation of phase sensitive detectors P2 and P3

3.1 Correction of phase error θ in the common source of the 30c/s reference

Suppose that, with switch SA set to Phase, P1 operates on an *in phase* 120c/s reference having a phase error ϕ, which can be represented by $\cos(\omega_c t + \phi)$. Signal $F_4(t)$ is applied to P2, which operates on the *quadrature* 30c/s reference having a phase error θ, say, represented by $\sin(\omega_m t + \theta)$. The output of P2 can be found by multiplying $F_4(t)$ by $\sin(\omega_m t + \theta)$ and rejecting all terms involving 2ω. The output of P2 is fed to meter M2 and will be a d.c. signal proportional to:

$$F_6(t) = (A+B)\cos\phi\sin\theta - (A-B)\sin\phi\cos\theta = A\sin(\theta - \phi) + B\sin(\theta + \phi) \quad \ldots\ldots\ldots 6$$

If the 120c/s reference has an error ϕ which is small compared with θ, the output of P2 will be a d.c. signal approximately proportional to:

$$F_7(t) \doteq (A+B)\sin\theta \quad \ldots\ldots\ldots\ldots\ldots 7$$

Correction of the phase of the common source of the 30c/s reference signals so that $\theta = 0$ is indicated by zero indication on meter M2.

3.2 Correction of phase error in the 120c/s reference

Suppose that, with switch SA turned to Set Null, P1 operates on a *quadrature* 120c/s reference having a phase error ϕ, which can be represented by $\sin(\omega_c t + \phi)$. Signal $F_2(t)$ is applied to P3, which operates on the *in phase* 30c/s reference having a phase error θ, say, represented by $\cos(\omega_m t + \theta)$. The output of P3 can be found by multiplying $F_2(t)$ by $\cos(\omega_m t + \theta)$ and rejecting all terms involving $2\omega_m$. The output of P3 is fed to meter M3 and will be a d.c. signal proportional to:

$$F_8(t) = (A+B)\sin\phi\cos\theta + (A-B)\cos\phi\sin\theta = A\sin(\phi + \theta) + B\sin(\phi - \theta) \quad \ldots\ldots\ldots 8$$

If the phase of the common source of the 30c/s reference is correct, i.e. $\theta = 0$, the output of P3 is a d.c. signal proportional to:

$$F_9(t) = (A+B)\sin\phi \quad \ldots\ldots\ldots\ldots\ldots 9$$

Correction of the phase of the 120c/s reference so that $\phi = 0$ is indicated by zero reading on M3.

3.3 Measurement of percentage modulation depth

Suppose that, with switch SA set to Mod Depth, an

in phase 120c/s reference having a phase error ϕ, $\cos(\omega_c t + \phi)$, is applied to P1, and an *in phase* 30c/s reference having a phase error θ, $\cos(\omega_m t + \theta)$, is applied to P3. The output of P3 is found by multiplying $F_4(t)$ by $\cos(\omega_m t + \theta)$ and rejecting all terms involving $2\omega_m$ or putting $(\phi + \pi/2)$ for ϕ in $F_8(t)$. The output of P3 is fed to meter M2 and is a d.c. signal proportional to:

$$F_{10}(t) = (A+B)\cos\phi\cos\theta - (A-B)\sin\phi\sin\theta$$

$$= A\cos(\phi + \theta) + B\sin(\phi - \theta) \quad \ldots\ldots\ldots 10$$

If both reference signals are correctly phased, i.e. $\phi = 0$ and $\theta = 0$, the signal applied to M2 will be a d.c. signal proportional to:

$$F_{11}(t) = A+B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 11$$

At the Mod Depth setting of the Function switch a d.c. proportional to the carrier amplitude is fed to M2 in opposition to $F_{11}(t)$. The Modulation Depth control is used to adjust the meter reading to zero, the control being calibrated in percentage depth of modulation.

3.4 Measurement of percentage d.d.m.

Suppose that, with switch SA set to D.D.M., a *quadrature* 120c/s reference having a phase error ϕ, $\sin(\omega_c t + \phi)$, is applied to P1 and a *quadrature* 30c/s reference having phase θ, $\sin(\omega_m t + \theta)$, is applied to P2. The output of P2 is found by multiplying $F_2(t)$ by $\sin(\omega_m t + \theta)$ and rejecting all terms involving $2\omega_m$. The output of P2 is applied to meter M2 and is a d.c. signal proportional to:

$$F_{12}(t) = (A+B)\sin\phi\sin\theta + (A-B)\cos\phi\cos\theta$$

$$= A\sin(\phi - \theta) - B\cos(\phi + \theta) \quad \ldots\ldots\ldots 12$$

If both references are correctly phased, i.e. $\phi = \theta$ and $\theta = 0$, the signal applied to M2 will be a d.c. signal proportional to:

$$F_{13}(t) = A-B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 13$$

M2 is calibrated in percentage d.d.m.

Note: The output of P3, which will be proportional to $F_8(t)$, is applied to meter M3. Correction of the 120c/s reference can be made by adjusting the Set Null control for zero indication on meter M3.

3.5 Advantage of first adjusting the phase of the 30c/s reference

Equations $F_{12}(t)$ and $F_8(t)$ represent the input to meters M2 and M3 for measurement of percentage d.d.m. and correction of the phase of the 120c/s reference respectively.

a Error in 30c/s reference

If the phase of the 120c/s reference is correctly adjusted so that $\phi = 0$, the equations reduce to:

$$F_{14}(t) = (A-B)\cos\theta$$

applied to d.d.m. meter M2 $\ldots\ldots\ldots 14$

$$F_{15}(t) = (A-B)\sin\theta$$

applied to 120c/s phase meter M3 15

Thus, for zero d.d.m., i.e. A=B, both meters indicate zero regardless of the value of θ because $F_{14}(t)$ and $F_{15}(t)$ become zero when A=B. If $A \neq B$ and $\theta = 0$ the phase meter M3 indicates zero [$F_{15}(t)$ becomes zero when $\theta = 0$] and the d.d.m. meter M2 will give an indication proportional to A–B [$F_{14}(t)$ becomes A–B when $\theta = 0$]. An error of a few degrees in the phase of the common source of the 30c/s reference will have very little effect on the indication on meter M2 because $\sin\theta$ is very small for small values of θ.

b Error in 120c/s reference

If the 30c/s reference phase is correctly adjusted, i.e. $\theta = 0$, the equations $F_{12}(t)$ and $F_9(t)$ reduce to:

$$F_{16}(t) = (A-B)\cos\phi$$

applied to d.d.m. meter M2 $\ldots\ldots\ldots 16$

$$F_{17}(t) = (A+B)\sin\phi$$

applied to 120c/s phase meter M3 17

Now, if A=B, the d.d.m. indication on meter M2 will correctly be zero regardless of the value of ϕ, but if ϕ is not zero it will be clearly evident on the phase meter since $(A+B)\sin\phi$ will be relatively large even for small values of ϕ.

This simple analysis shows that there is an advantage to be gained by adjusting first the common phase of the 30c/s reference signals; even a small error in the phase of the 120c/s reference signal will then be immediately evident on the phase meter.

APPENDIX 4 (fig. 14)

Wien bridge amplifier

Fig. 14d is the equivalent circuit of the Wien bridge section of fig. 14a. From fig. 14d it is seen that:

$$\frac{i_4}{i_3} = \frac{G}{G + pC} \quad \text{where } G = \frac{1}{R}$$

$$\frac{i_3}{i_2} = \left[\frac{pC(G+pC)}{G + pC + pC}\right] \div \left[G + \frac{pC(G + pC)}{G + pC + pC}\right]$$

$$= \frac{pC(G+pC)}{G^2+3pCG+p^2C^2}$$

$$\frac{i_4}{i_2} = \frac{G}{G+pC} \cdot \frac{i_3}{i_2} = \frac{pCG}{G^2 + 3pCG + p^2C^2}$$

$$\therefore \frac{i_4}{i_2} = \frac{pCR}{1 + 3pCR + p^2C^2R^2}$$

Now considering fig. 14a

$$\frac{i_f}{i_1} = \frac{Ai_f}{i_2} = \left[\frac{A.i_4}{i_2} \cdot \frac{Ro}{Ro+Rf}\right]$$

$$\therefore \frac{i_f}{i_1} = \frac{Ro}{R_oR_f/(R_o+R_f)}\left[\frac{ApCR}{1 + 3pCR+p^2C^2R^2}\right]$$

But $\frac{i_f}{i_{in}} = \frac{i_f}{i_1-i_f} = \left(\frac{i_f}{i_1}\right) \div \left(1 - \frac{i_f}{i_1}\right)$

$$= \frac{Ro}{Ro+Rf}\left[\frac{ApCR}{1 + 3pCR+p^2C^2R^2}\right] \div \left[1 - \frac{ApCR}{1 + 3pCR+p^2C^2R^2}\right]$$

$$\therefore \frac{i_f}{i_{in}} = \left[\frac{RoApCR}{Ro + Rf}\right] \div \left[1 + \left(3 - \frac{RoA}{Ro+Rf}\right) pCR + p^2C^2R^2\right]$$

$$i_o = \frac{R_f}{Ro} \cdot i_f$$

$$\therefore \frac{i_o}{i_n} = \left[\frac{R_fA_pCR}{Ro+R_f}\right] \div \left[1 + \left(3 - \frac{RoA}{Ro+R_f}\right) pCR + p^2C^2R^2\right]$$

In the special case where $Ro=R_f$, i.e. $i_o = i_f$

$$\frac{i_o}{i_n} = \left[\frac{ApCR}{2}\right] \div \left[1 + \left(3 - \frac{A}{2}\right)pCR + p^2C^2R^2\right]$$ from which:

$$Q = \frac{1}{3 - \frac{A}{2}} \quad \text{and}$$

$$A_o = \left[\frac{A}{2}\right] \div \left[3 - \frac{A}{2}\right] = \frac{A}{6 - A}$$

where Ao is the gain at resonance

When $Q = 6 \quad 3-\frac{A}{2} = \frac{1}{6}$

$$\therefore A = \frac{34}{6} = 5.667$$

$$A_o = \frac{5.667}{6-5.667} = \underline{17}$$

APPENDIX 5

The notch filter (fig. 17)

Considering the circuit of fig. 17c and assuming VT1 to be a perfect transistor:

$$\frac{e_2}{e_1} = -\left[\frac{\text{collector load}}{\text{emitter load}}\right] = -\left[\frac{\text{emitter admittance}}{\text{collector admittance}}\right]$$

$$= -\left[\frac{g_3 + g_1pC_1/(g_1 + pC_1)}{g_2 + pC_2}\right]$$

$$= -\left[\frac{g_1g_3 + (g_1 + g_3)\,pC_1}{g_1g_2 + g_1pC_2 + g_2pC_1 + p^2C_1C_2}\right]$$

$$= -\left[\frac{R_2 + (R_1R_2 + R_2R_3)pC_1}{R_3[1 + (R_1C_1 + R_2C_2)p + R_1R_2p^2C_1C_2]}\right] \ldots 1$$

Suppose $R_1 = R_2 = R$ and $C_1 = C_2 = C$
In practice there is a limit to the ratio of R_3 to R
Suppose $R_3 = 10R$
Substituting these values in equation 1:

$$\frac{e_2}{e_1} = -\left[\frac{R + (R^2 + 10R^2)pC}{10R\,(1 + 2RpC + R^2p^2C^2)}\right]$$

$$= -\left[\frac{0.1 + 1.1RpC}{1 + 2RpC + R^2p^2C^2}\right]$$

If mixing resistors R4, R5 are chosen so that $e_o = e_1 + 1.82e_2$

$$\frac{e_o}{e_1} = \frac{e_1 + 1.82e_2}{e_1} =$$

$$1 - \frac{0.18 + 2RpC}{1 + 2RpC + R^2p^2C^2} \quad \ldots\ldots\ldots\ldots 2$$

$$\therefore \frac{e_o}{e_1} = \frac{0.82 + R^2p^2C^2}{1 + 2RpC + R^2p^2C^2}$$

Equation 2 is the transfer function of a perfect notch filter having a slightly skew characteristic.

APPENDIX 6

Calibration (fig. 29)

To measure d.d.m. at a value other than zero requires a standard of reference against which the instrument may be calibrated. For this purpose a single time constant comprising a standard resistor and capacitor is used which provides a means of calibration and a checking facility. Variable resistor RV101 and capacitor C102 (unit 1) form the calibration time constant in the N100 instrument. Fig. 29a is a simplified circuit which illustrates the initial calibration process. The input to the N100 is supplied by suitable audio frequency sources capable of injecting 90c/s and 150c/s signals of equal amplitude. The instrument is correctly set up and the Function switch set to 0.2% D.D.M. The output from the measurement channel of the N100 is then proportional to the difference between the amplitudes of the two tones, A–B, and the amplitudes of the input signals are adjusted for zero reading on the meter M2. Depressing the Calibrate switch S3 brings capacitor C102 into circuit through closed switch contact S3A. The difference in attenuation of the 90c/s and 150c/s components of the input signal causes the meter reading to change. The setting of RV101 and the value of C102 are selected at production so that the meter reading is −0.2% under these conditions.

In practice two methods of checking the calibration may be used. These are:

1 Normal method: Fig. 29b is a simple circuit illustrating the normal method of checking calibration. The instrument is set up for approximately correct input level and correct phase of the 30c/s and 120c/s references as instructions 1 to 10 or 14 to 18 of p.8 & 9. The Function switch is turned to Mod Depth so that a signal proportional to the sum of the amplitudes of the two I.L.S. tones, A+B, is fed to meter M2. The Calibrate switch is depressed and brings capacitor C102 into circuit thus causing an unequal attenuation of the 90c/s and 150c/s components of the input signal. In addition, switch contacts S3B change over to feed a d.c. signal through meter M2 in opposition to the signal proportional to A+B from the measurement channel of the N100. The d.c. signal is fed from the wiper of RV9 which is connected in series with R21 across the stabilised +11V supply. RV9 is set up at production so that in subsequent operation, the correct input level is obtained by adjusting the Set Level control for zero reading on meter M2.

2 Special method: The special method of d.d.m. calibration requires a suitable audio frequency source to supply 90c/s and 150c/s signals of equal amplitude to the N100. The instrument is set up for approximately correct input level and correct phase of the 30c/s and 120c/s references, as operating instructions 1 to 10 or 14 to 18 of p.8 & 9. The Function switch is then set to 0.2% D.D.M. and the Calibrate switch depressed, see fig. 29a. The Set Level control is adjusted until the meter reads exactly −0.2%.

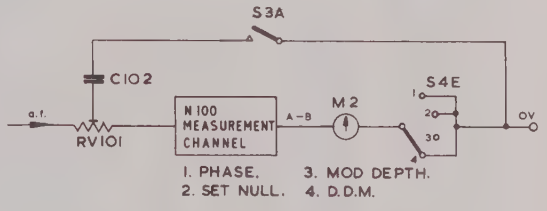


FIG 29a SIMPLE CIRCUIT ILLUSTRATING SPECIAL CALIBRATION CHECK.

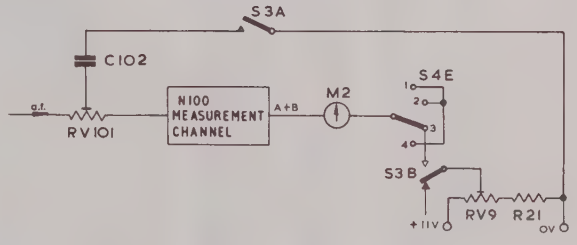


FIG 29b SIMPLE CIRCUIT ILLUSTRATING NORMAL CALIBRATION CHECK.

RV = GP

COMPONENTS LIST

NOTE: For components with reference numbers:
1 to 23 see unit interconnection circuit at the end of the book.
100 series see buffer amplifier and multiplier, unit 1, fig. 13.
200 series see 30c/s amplifier and phase sensitive detectors, unit 2, fig. 15.
300 series see 90c/s and 150c/s filter and squarer unit 3, fig. 18.
400 series see reference generator, unit 4, fig. 20.
500 series see binary unit 5, fig. 22.
600 series see sync pulse generator, unit 6, fig. 25.
700 series see receiver, fig. 11.
800 series see power supply, fig. 9.
900 series see sync pulse filter, fig. 13a.
1000 series see DDM board, fig. 27

Resistors

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R1	2.7K	2	Fixed, high stability	Welwyn	C21
R2	1M	1	Fixed, metal oxide	Electrosil	TR6
R3	1.1M	1	Fixed, metal film	Welwyn	4033G
R4	330K	1	Fixed, metal oxide	Electrosil	TR5
R5	62K	1	Fixed, metal oxide	Electrosil	TR5
R6	1K	5	Fixed, metal oxide	Electrosil	TR5
R7	560Ω	5	Fixed, metal oxide	Electrosil	TR5
R8	1.2M	1	Fixed, metal film	Welwyn	4033G
R9	560Ω	1	Fixed, metal oxide	Electrosil	TR5
R10	560Ω	5	Fixed, ¼W, high stability	Welwyn	C21
R11	270Ω	10	Fixed	Style*	RC7K
R12	62K	2	Fixed, high stability	Welwyn	C21
R13	150Ω	10	Fixed	Style*	RC7K
R14	62K	2	Fixed, high stability	Welwyn	C21
R15	220Ω	10	Fixed	Style*	RC7K
R16	47Ω	10	Fixed	Style*	RC7K
R17	10K	10	Fixed, high stability	Style*	RC7K
R18	62K	1	Fixed, metal oxide	Electrosil	TR5
R19	Selected		Fixed, A.I.C.	Style*	RC7K
R20	Selected		Fixed, high stability, A.I.C.	Welwyn	C21
R21	3.3K	1	Fixed, metal oxide	Electrosil	TR5
R22	Selected		Fixed, high stability A.I.C.	Welwyn	C21
R23	1K	10	Fixed	Style*	RC7K
R101	3.3K	10	Fixed	Style*	RC7K
R102	1K	10	Fixed	Style*	RC7K
R103	1K	10	Fixed	Style*	RC7K
R104	3.9K	2	Fixed, metal oxide H.S.	Electrosil	TR5
R105	6.8K	10	Fixed	Style*	RC7K
R106	18K	10	Fixed	Style*	RC7K
R107	8.2K	10	Fixed	Style*	RC7K
R108	13K	1	Fixed, metal oxide, H.S.	Electrosil	TR5
R109	4.7K	10	Fixed	Style*	RC7K
R110	470Ω	10	Fixed	Style*	RC7K
R111	12K	10	Fixed	Style*	RC7K
R112	470Ω	10	Fixed	Style*	RC7K
R113	100Ω	10	Fixed	Style*	RC7K
R114	470Ω	10	Fixed	Style*	RC7K
R115	100Ω	10	Fixed	Style*	RC7K
R116	10K	10	Fixed	Style*	RC7K
R117	10K	10	Fixed	Style*	RC7K
R118	6.8K	10	Fixed	Style*	RC7K
R119	12K	10	Fixed	Style*	RC7K
R120	6.8K	10	Fixed	Style*	RC7K
R121	470Ω	10	Fixed	Style*	RC7K
R122	3.3K	10	Fixed	Style*	RC7K
R123	3.3K	10	Fixed	Style*	RC7K
R124	13K	1	Fixed, metal oxide, H.S.	Electrosil	TR5
R125	560Ω	2	Fixed, metal oxide	Electrosil	TR5
R126	Selected	2	Fixed, metal oxide, A.I.C.	Electrosil	TR5
R127	1K	10	Fixed	Style*	RC7K
R128	Selected	2	Fixed, metal oxide, A.I.C.	Electrosil	TR5
R201	220K	10	Fixed	Style*	RC7K
R202	10K	10	Fixed	Style*	RC7K
R203	15K	10	Fixed	Style*	RC7K
R204	20K	0.5	Fixed, wirewound	Alma	CD4

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R205	5.6K	1	Fixed ¼W, high stability	Plessey	Metallux AT/E
R206	10K	0.5	Fixed, wirewound	Alma	CD4
R207	1.2K	1	Fixed, ¼W, high stability	Plessey	Metallux AT/E
R208	200K	5	Fixed, high stability	Welwyn	C21
R209	21.5K	0.5	Fixed, wirewound	Alma	CD4
R210	470Ω	10	Fixed	Style*	RC7K
R211	470K	10	Fixed	Style*	RC7K
R212	10K	10	Fixed	Style*	RC7K
R213	15K	10	Fixed	Style*	RC7K
R214	20K	0.5	Fixed	Alma	CD4
R215	5.6K	1	Fixed, ¼W, high stability	Plessey	Metallux AT/E
R216	10K	0.5	Fixed wirewound	Alma	CD4
R217	1.2K	1	Fixed, ¼W, high stability	Plessey	Metallux AT/E
R218	470Ω	10	Fixed	Style*	RC7K
R219	21.5K	0.5	Fixed, wirewound	Alma	CD4
R220	15K	10	Fixed	Style*	RC7K
R221	10K	2	Fixed, high stability	Electrosil	TR4/C-07
R222	12K	10	Fixed	Style*	RC7K
R223	1.2K	10	Fixed	Style*	RC7K
R224	100Ω	10	Fixed	Style*	RC7K
R225	470Ω	10	Fixed	Style*	RC7K
R226	5.6K	10	Fixed	Style*	RC7K
R227	5.6K	10	Fixed	Style*	RC7K
R228	5.6K	10	Fixed	Style*	RC7K
R229	5.6K	10	Fixed	Style*	RC7K
R230	22K	10	Fixed	Style*	RC7K
R231	200K	5	Fixed, high stability	Welwyn	C21
R232	100K	10	Fixed	Style*	RC7K
R233	1.2M	1	Fixed, metal film	Welwyn	4033G
R234	10K	2	Fixed metal oxide	Electrosil	TR4/C-07
R235	1.2M	1	Fixed, metal film	Welwyn	4033G
R301	10K	5	Fixed, high stability	Welwyn	C21
R302	Not used				
R303	22K	5	Fixed, high stability	Welwyn	C21
R304	2.7K	2	Fixed, high stability	Welwyn	C21
R305	2.2K	2	Fixed, high stability	Welwyn	C21
R306	10K	5	Fixed, high stability	Welwyn	C21
R307	4.7K	5	Fixed, high stability	Welwyn	C21
R308	18K	5	Fixed high stability	Welwyn	C21
R309	100K	10	Fixed	Style*	RC7K
R310	22K	10	Fixed	Style*	RC7K
R311	15K	10	Fixed	Style*	RC7K
R312	470Ω	10	Fixed	Style*	RC7K
R313	470Ω	10	Fixed	Style*	RC7K
R314	1K	10	Fixed	Style*	RC7K
R315	12K	10	Fixed	Style*	RC7K
R316	22K	10	Fixed	Style*	RC7K
R317	100Ω	10	Fixed	Style*	RC7K
R318	100Ω	10	Fixed	Style*	RC7K
R319	Not used				
R320	12K	5	Fixed, high stability	Welwyn	C21
R321	1.6K	2	Fixed, high stability	Welwyn	C21
R322	15K	5	Fixed, high stability	Welwyn	C21
R323	1.6K	2	Fixed, high stability	Welwyn	C21
R324	62K	5	Fixed, high stability	Welwyn	C21
R325	33K	5	Fixed, high stability	Welwyn	C21
R326	Selected		Fixed, A.I.C.	Style*	RC7K
R327	15K	10	Fixed	Style*	RC7K
R328	6.8K	5	Fixed, high stability	Welwyn	C21
R329	22K	1	Fixed, high stability	Welwyn	C21
R330	11K	1	Fixed, high stability	Welwyn	C21
R331	1.5K	5	Fixed, high stability	Welwyn	C21
R332	22K	1	Fixed, high stability	Welwyn	C21
R333	100K	10	Fixed	Style*	RC7K
R334	15K	10	Fixed	Style*	RC7K
R335	18K	10	Fixed	Style*	RC7K
R336	470Ω	10	Fixed	Style*	RC7K
R337	2.7K	10	Fixed	Style*	RC7K
R338	470Ω	10	Fixed	Style*	RC7K

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R339	18K	10	Fixed	Style*	RC7K
R340	1K	10	Fixed	Style*	RC7K
R341	12K	10	Fixed	Style*	RC7K
R342	100Ω	10	Fixed	Style*	RC7K
R343	100Ω	10	Fixed	Style*	RC7K
R344	1M	10	Fixed	Style*	RC7K
R345	22K	10	Fixed	Style*	RC7K
R346	3.3K	10	Fixed	Style*	RC7K
R347	4.7K	10	Fixed	Style*	RC7K
R348	2.2K	10	Fixed	Style*	RC7K
R349	27K	10	Fixed	Style*	RC7K
R350	22K		Fixed	Style*	RC7K
R351	22K		Fixed		
R352	18K		Fixed		
R353	11K		Fixed		
R354	1.2K		Fixed		
R355	Not used				
R356	220K		Fixed		
R357	22K		Fixed		
R358	18K		Fixed		
R359	15K		Fixed		
R360	47K		Fixed		
R361	18K		Fixed		
R362	180K		Fixed		
R363	47K		Fixed		
R401	2.2K	10	Fixed	Style*	RC7K
R402	2.2K	10	Fixed	Style*	RC7K
R403	1.5K	10	Fixed	Style*	RC7K
R404	10K	1	Fixed, high stability	Welwyn	C21
R405	1.8K	5	Fixed, high stability	Welwyn	C21
R406	10K	1	Fixed, high stability	Welwyn	C21
R407	1.5K	10	Fixed	Style*	RC7K
R408	2.2K	10	Fixed	Style*	RC7K
R409	270Ω	10	Fixed	Style*	RC7K
R410	180Ω	10	Fixed	Style*	RC7K
R411	2.2K	10	Fixed	Style*	RC7K
R412	3.3K	10	Fixed	Style*	RC7K
R413	2.2K	10	Fixed	Style*	RC7K
R414	8.2K	10	Fixed	Style*	RC7K
R415	1M	5	Fixed, high stability	Welwyn	C21
R416	180K	10	Fixed	Style*	RC7K
R417	4.7K	10	Fixed	Style*	RC7K
R418	10K	10	Fixed	Style*	RC7K
R419	10K	10	Fixed	Style*	RC7K
R420	10K	10	Fixed	Style*	RC7K
R421	22K	5	Fixed, high stability	Welwyn	C21
R422	3.3K	5	Fixed, high stability	Welwyn	C21
R423	10K	10	Fixed	Style*	RC7K
R424	10K	10	Fixed	Style*	RC7K
R425	3.9K	10	Fixed	Style*	RC7K
R426	15K	10	Fixed	Style*	RC7K
R427	12K	10	Fixed	Style*	RC7K
R428	5.6K	10	Fixed	Style*	RC7K
R429	68K	10	Fixed	Style*	RC7K
R430	6.8K	10	Fixed	Style*	RC7K
R431	2.2K	10	Fixed	Style*	RC7K
R432	2.7K	10	Fixed	Style*	RC7K
R501	10K	10	Fixed	Style*	RC7K
R502	1.2K	10	Fixed	Style*	RC7K
R503	6.8K	10	Fixed	Style*	RC7K
R504	82K	5	Fixed	Style*	RC7K
R505	82K	5	Fixed	Style*	RC7K
R506	6.8K	10	Fixed	Style*	RC7K
R507	1.2K	10	Fixed	Style*	RC7K
R508	10K	10	Fixed	Style*	RC7K
R509	12K	10	Fixed	Style*	RC7K
R510	12K	10	Fixed	Style*	RC7K
R511	10K	10	Fixed	Style*	RC7K
R512	1.2K	10	Fixed	Style*	RC7K

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R513	6.8K	10	Fixed	Style*	RC7K
R514	82K	5	Fixed	Style*	RC7K
R515	82K	5	Fixed	Style*	RC7K
R516	6.8K	10	Fixed	Style*	RC7K
R517	1.2K	10	Fixed	Style*	RC7K
R518	10K	10	Fixed	Style*	RC7K
R519	1K	10	Fixed	Style	RC7K
R520	8.2K	5	Fixed, high stability	Welwyn	C21
R521	4.7K	5	Fixed	Welwyn	C21
R522	6.8K	10	Fixed	Style*	RC7K
R523	47K	5	Fixed	Style*	RC7K
R525	6.8K	10	Fixed	Style*	RC7K
R526	330Ω	5	Fixed	Style*	RC7K
R527	18K	10	Fixed	Style*	RC7K
R528	12K	10	Fixed	Style*	RC7K
R529	10K	10	Fixed	Style*	RC7K
R530	1.2K	10	Fixed	Style*	RC7K
R531	6.8K	10	Fixed	Style*	RC7K
R532	82K	5	Fixed	Style*	RC7K
R533	82K	5	Fixed	Style*	RC7K
R534	6.8K	10	Fixed	Style*	RC7K
R535	1.2K	10	Fixed	Style*	RC7K
R536	10K	10	Fixed	Style*	RC7K
R537	10K	10	Fixed	Style*	RC7K
R538	1.2K	10	Fixed	Style*	RC7K
R539	6.8K	10	Fixed	Style*	RC7K
R540	82K	5	Fixed	Style*	RC7K
R541	82K	5	Fixed	Style*	RC7K
R542	6.8K	10	Fixed	Style*	RC7K
R543	1.2K	10	Fixed	Style*	RC7K
R544	10K	10	Fixed	Style*	RC7K
R545	12K	10	Fixed	Style*	RC7K
R546	10K	10	Fixed	Style*	RC7K
R547	1.2K	10	Fixed	Style*	RC7K
R548	6.8K	10	Fixed	Style*	RC7K
R549	82K	5	Fixed	Style*	RC7K
R550	82K	5	Fixed	Style*	RC7K
R551	6.8K	10	Fixed	Style*	RC7K
R552	1.2K	10	Fixed	Style*	RC7K
R553	10K	10	Fixed	Style*	RC7K
R554	12K	10	Fixed	Style*	RC7K
R555	8.2K	5	Fixed	Style*	RC7K
R556	12K	10	Fixed	Style*	RC7K
R557	27K				
R601	18K	10	Fixed	Style*	RC7K
R602	12K	10	Fixed	Style*	RC7K
R603	6.8K	10	Fixed	Style*	RC7K
R604	5.6K	10	Fixed	Style*	RC7K
R605	6.8K	10	Fixed	Style*	RC7K
R606	8.2K	10	Fixed	Style*	RC7K
R607	180K	5	Fixed, high stability	Welwyn	C21
R608	10K	10	Fixed	Style*	RC7K
R609	680Ω	10	Fixed	Style*	RC7K
R610	5.6K	10	Fixed	Style*	RC7K
R611	47K	10	Fixed	Style*	RC7K
R612	18K	10	Fixed	Style*	RC7K
R613	15K	10	Fixed	Style*	RC7K
R614	1K	10	Fixed	Style*	RC7K
R615	6.8K	10	Fixed	Style*	RC7K
R616	1K	10	Fixed	Style*	RC7K
R617	5.6K	10	Fixed	Style*	RC7K
R618	150K	2	Fixed, metal oxide	Electrosil	TR5
R619	8.2K	10	Fixed	Style*	RC7K
R620	680Ω	10	Fixed	Style*	RC7K
R621	6.8K	10	Fixed	Style*	RC7K
R622	180	10	Fixed	Style*	RC7K
R623	47K	10	Fixed	Style*	RC7K
R624	18K	10	Fixed	Style*	RC7K
R625	270Ω	10	Fixed	Style*	RC7K

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R626	1.5K	10	Fixed	Style*	RC7K
R627	2.2K	10	Fixed	Style*	RC7K
R628	6.8K	10	Fixed	Style*	RC7K
R629	6.8K	10	Fixed	Style*	RC7K
R630	12K	10	Fixed	Style*	RC7K
R631	10K	10	Fixed	Style*	RC7K
R632	1.5K	10	Fixed	Style*	RC7K
R701	8.2K	2	Fixed, high stability	Welwyn	C21
R702	6.8K	10	Fixed	Style*	RC7K
R703	Not used				
R704	150Ω	10	Fixed	Style*	RC7K
R705	1K	10	Fixed	Style*	RC7K
R706	12K	10	Fixed	Style*	RC7K
R707	1.2K	10	Fixed	Style*	RC7K
R708	1K	10	Fixed	Style*	RC7K
R709	Not used				
R710	1K	10	Fixed	Style*	RC7K
R711	10K	10	Fixed	Style*	RC7K
R712	Not used				
R713	1.8K	10	Fixed	Style*	RC7K
R713A	Selected		A.I.C.	Style*	RC7K
R714	1.2K	10	Fixed	Style*	RC7K
R715	8.2K	10	Fixed	Style*	RC7K
R716	680Ω	2	Fixed, high stability	Welwyn	C21
R717	560Ω	2	Fixed, high stability	Welwyn	C21
R718	10K	10	Fixed	Style*	RC7K
R719	2.7K	10	Fixed	Style*	RC7K
R720	8.2K	10	Fixed	Style*	RC7K
R721	560Ω	10	Fixed	Style*	RC7K
R722	3.3K	10	Fixed	Style*	RC7K
R723	6.8K	10	Fixed	Style*	RC7K
R724	12K	10	Fixed	Morgan	Morganite CB
R725	270Ω	10	Fixed	Style*	RC7K
R726	22K	10	Fixed	Morgan	Morganite X
R727	330Ω	5	Fixed, high stability	Welwyn	C21
R728	27Ω	10	Fixed	Style*	RC7K
R729	27Ω	10	Fixed	Style*	RC7K
R730	3.9K	10	Fixed	Style*	RC7K
R731	3.3K	10	Fixed	Style*	RC7K
R732	150K	2	Fixed, high stability	Welwyn	C21
R733	430K	2	Fixed, high stability	Welwyn	C21
R734	3.9K	10	Fixed	Style*	RC7K
R735	2K	2	Fixed high stability	Welwyn	C21
R736	3.3K	5	Fixed, high stability	Welwyn	C21
R737	22K	10	Fixed	Style*	RC7K
R738	2.2K	5	Fixed, high stability	Welwyn	C21
R739	3.9K	5	Fixed, high stability	Welwyn	C21
R740	390Ω	5	Fixed, high stability	Welwyn	C21
R741	390Ω	5	Fixed, high stability	Welwyn	C21
R742	1.8K	10	Fixed	Style*	RC7K
R743	680Ω	10	Fixed	Style*	RC7K
R744	330Ω	10	Fixed	Style*	RC7K
R745	4.7K	5	Fixed, high stability	Welwyn	C21
R746	100Ω	10	Fixed	Style*	RC7K
R747	3.9K	10	Fixed	Style*	RC7K
R748	330Ω	10	Fixed	Style*	RC7K
R749	12K	10	Fixed	Style*	RC7K
R750	1K	10	Fixed	Style*	RC7K
R751	12K	10	Fixed	Style*	RC7K
R752	10K	10	Fixed	Style*	RC7K
R753	1.8K	10	Fixed	Style*	RC7K
R754	470Ω	10	Fixed	Style*	RC7K
R755	1K	10	Fixed	Style*	RC7K
R756	Selected		Fixed, A.I.C.		
R757	Not used				
R758	100Ω	10	Fixed	Style*	RC7K
R759	6.8K	10	Fixed	Style*	RC7K
R760	2.7K	10	Fixed	Style*	RC7K
R801	1K	10	Fixed	Style*	RC7K
R802	1K	10	Fixed	Style*	RC7K

* or any other manufacturer

Reference	Value	Per cent tolerance	Description	Manufacturers	
				Name	Type
R803	22K	10	Fixed	Style*	RC7K
R804	22K	10	Fixed	Style*	RC7K
R805	4.7K	10	Fixed	Style*	RC7K
R806	4.7K	10	Fixed	Style*	RC7K
R807	1K	5	Fixed, Metal oxide	Electrosil	TR5
R808	3.3K	5	Fixed, Metal oxide	Electrosil	TR5
R809	3.3K	5	Fixed, Metal oxide	Electrosil	TR5
R810	1K	5	Fixed, Metal oxide	Electrosil	TR5
R811	15Ω	10	Fixed	Style*	RC7K
R812	4.7Ω	0.5Ω	Fixed	Style*	RC7K
R813	10Ω	10	Fixed	Morgan	RC7H Morganite Y
R814	10Ω	10	Fixed	Morgan	RC7H Morganite Y
R900	15K	5	Fixed, high stability	Welwyn	C22
R901	560Ω	1	Fixed, high stability	Welwyn	C22
R902	10K	1	Fixed, high stability	Welwyn	C22
R903	10K	1	Fixed, high stability	Welwyn	C22
R904	39K	5	Fixed, high stability	Welwyn	C22
R1001	150K	1	Fixed		
R1002	56K	1	Fixed		
R1003	82K	1	Fixed		
R1004	22K	1	Fixed		
R1005	3.3K	5	Fixed		
R1006	1K	0.1	Fixed		
R1007	1K	0.1	Fixed		
R1008	1K	0,1	Fixed		
R1009	100Ω	0.1	Fixed		
R1010	100Ω	0.1	Fixed		
R1011	100Ω	0.1	Fixed		
R1012	100Ω	0.1	Fixed		
R1013	100Ω	0.1	Fixed		
R1014	100Ω	0.1	Fixed		
R1015	100Ω	0.1	Fixed		
R1016	100Ω	0.1	Fixed		
R1017	100Ω	0.1	Fixed		
R1018	100Ω	0.1	Fixed		
R1019	Not used				
R1020	Not used				
R1021	4.7K	5	Fixed		
R1022	Not used				
R1023	Not used				
R1024	4.7K	5	Fixed		
R1025	47K	0.5	Fixed		
R1026	47K	0.5	Fixed		
R1027	8.2K	5	Fixed		
R1028	180K	5	Fixed		
R1029	1K	5	Fixed		
R1030	270K	5	Fixed		
R1031	2.2K	5	Fixed		
R1032	820K	5	Fixed		
R1033	180K	5	Fixed		
R1034	10K				
R1035	10K				
R1036	10K				

Potentiometers

Reference	Value	Manufacturers	
		Name	Type
RV1	500Ω	Plessey	G
RV2	500Ω	Colvern	CLR5001
RV3	1K	Reliance	CW15
RV4	25K	Colvern	CLR4239/10
RV5	250K	Plessey	E
RV6	50K	Plessey	E

Reference	Value	Manufacturers	
		Name	Type
RV7	10K	Colvern	CLR5001
RV8	250Ω	Plessey	G
RV9	500Ω	Reliance	CW35
RV101	1K	Plessey*	G
RV102	500Ω	Plessey	G
RV201	500Ω	Reliance	CW15

Reference	Value	Manufacturers	
		Name	Type
RV202	Not used		
RV203	500Ω	Reliance	CW15
RV204	1K	Plessey	G
RV301	4.7K	Plessey	G
RV302	5K	Plessey	G
RV303	1K	Plessey	G
RV304	4.7K	Plessey	G
RV401	2.5K	Plessey	G
RV402	500Ω	Plessey	G
RV501	5K	Plessey	G
RV601	5K	Plessey	G
RV602	100K	Plessey	G

Reference	Value	Manufacturers	
		Name	Type
RV603	150K	Plessey	G
RV604	82K	Plessey	G
RV701	3.3K	Plessey	G Mk 5
RV702	820Ω	Plessey	G Mk 5
RV703	1.2K	Plessey	G Mk 5
RV704	15K	Reliance	CW35 Standard
RV801	25K	Plessey	G
RV802	25K	Plessey	G
RV803	2K	Reliance	MW
RV804	2K	Reliance	MW
RV1001	10K	Plessey	G
RV1002	2.5K	Plessey	G
RV1003	180	Erie/Davall	80/S

Capacitors

Reference	Value	Tolerance or rating	Description	Manufacturers	
				Name	Type
C1	47μF	16V	Fixed, electrolytic	Printilyt	
C2	47μF	16V	Fixed, electrolytic	Printilyt	
C3	47μF	16V	Fixed, electrolytic	Printilyt	
C4	50μF	6V	Fixed	Hunts	MEW9T
C5	50μF	6V	Fixed	Hunts	MEW9T
C101	1000μF		Fixed, electrolytic	Hunts	MEF27AT
C102	0.22μF	10%,150V	Fixed, polyester	G.E.C.	P.F.T.
C103	0.02μF		Fixed	Hunts	W95/BD14
C104	0.02μF		Fixed	Hunts	W95/BD14
C105	470μF	25V	Fixed, electrolytic	Mullard	108-16471
C106	470μF	25V	Fixed, electrolytic	Mullard	108-16471
C107	25μF	15V	Fixed, electrolytic	Hunts	MEW17T
C108	25μF	15V	Fixed, electrolytic	Hunts	MEW17T
C109	2μF		Fixed	Hunts	W49/B504KZ
C110	2μF		Fixed	Hunts	W49/B504KZ
C111	1μF		Fixed	Hunts	W49/B503KY
C112	1μF		Fixed	Hunts	W49/B503KY
C113	Selected		A.I.C.		
C201	100μF		Fixed, electrolytic	Plessey	CE1222
C202	0.53μF		Fixed	T.M.C.	J1423
C203	0.53μF		Fixed	T.M.C.	J1423
C204	500μF	12V	Fixed	Hunts	MEF25AT
C205	100μF		Fixed, electrolytic	Plessey	CE1222
C206	0.53μF		Fixed	T.M.C.	J1423
C207	0.53μF		Fixed	T.M.C.	J1423
C208	500μF	12V	Fixed	Hunts	MEF25AT
C209	500μF	12V	Fixed	Hunts	MEF25AT
C210	500μF	12V	Fixed	Hunts	MEF25AT
C211	500μF	12V	Fixed	Hunts	MEF25AT
C212	10μF	6V	Fixed	Plessey	CE1221
C213	10μF	6V	Fixed	Plessey	CE1221
C214	470μF	6.3V	Fixed	Plessey	439/1/05420/001
C215	1000pF		Fixed	Erie	K350081/831
C301	220μF	35V	Fixed, electrolytic	Printilyt	
C302	220μF	35V	Fixed, electrolytic	Printilyt	
C303	22μF	35V	Fixed, electrolytic	Printilyt	
C304	0.5μF	2%	Fixed	G.E.C.	A596
C305	0.5μF	2%	Fixed	G.E.C.	A596
C306	390pF		Fixed, high permittivity	Erie	K120051/K
C307,C308	Not used				
C309	220μF	35V	Fixed, electrolytic	Printilyt	
C310	220μF	35V	Fixed, electrolytic	Printilyt	
C311	0.1μF	5%, 160V	Fixed	G.E.C.	A596
C312	1μF	160V	Fixed	G.E.C.	A596
C313	25μF	35V	Fixed, electrolytic	Printilyt	
C314	1μF	160V	Fixed	G.E.C.	A596
C315	0.1μF		Fixed	T.M.C.	S125668
C316	0.1μF		Fixed	T.M.C.	S125668
C317	0.002μF	500V	Fixed	Wima	Tropyfol F

Reference	Value	Tolerance or rating	Description	Manufacturers	
				Name	Type
C318	0.1μF	160V	Fixed	Mullard	C296/AA/A100K
C319	200μF	35V	Fixed, electrolytic	Printilyt	
C320	200μF	35V	Fixed, electrolytic	Printilyt	
C321	200μF	35V	Fixed, electrolytic	Printilyt	
C322	22pF	20%	Fixed, high permittivity	Erie	N750K
C323	10μF	35V	Fixed, electrolytic	Printilyt	
C324	1μF		Fixed		
C325	30pF		Fixed		
C326	0.01μF		Fixed		
C327	0.1μF		Fixed		
C328	30pF		Fixed		
C329	0.1μF		Fixed polystyrene H.S.		
C330	4.7nF		Fixed		
C331	30pF		Fixed		
C332	0.1μF		Fixed		
C333	0.1μF		Fixed polystyrene H.S.		
C401	100μF		Fixed, electrolytic	Plessey	CE1222
C402	100μF		Fixed, electrolytic	Plessey	CE1222
C403	0.15μF	2%, 50V	Fixed	T.M.C.	S126008
C404	0.15μF	2%, 50V	Fixed	T.M.C.	S126008
C405	Not used				
C406	100μF		Fixed, tantalum	S.T.C.	472/LWA/106AA
C407	2μF	1%, 160V	Fixed	G.E.C.	A596
C408	2μF	1%, 160V	Fixed	G.E.C.	A596
C409	0.22μF	250V	Fixed	Erie	51012-000-0224-01C-0251
C410	0.47μF	250V	Fixed	Erie	51012-000-0274-01C-0251
C411	0.01μF	100V	Fixed	Wima	Tropyfol F
C412	25μF		Fixed, electrolytic	Hunts	MEW17T
C413	0.1μF	10%, 160V	Fixed	Mullard	C296/AA/A100K
C414	10μF	63V	Fixed, electrolytic	Mullard	016/18109
C501	0.005μF		Fixed	Hunts	W95/BD12
C502	0.005μF		Fixed	Hunts	W95/BD12
C503	0.005μF		Fixed	Hunts	W95/BD12
C504	0.005μF		Fixed	Hunts	W95/BD12
C505	0.005μF		Fixed	Hunts	W95/BD12
C506	0.005μF		Fixed	Hunts	W95/BD12
C507	0.01μF	100V	Fixed	Wima	Tropyfol F
C508	0.05μF	1.1%	Fixed	T.M.C.	S126007
C509	0.005μF		Fixed	Hunts	W95/BD12
C510	0.005μF		Fixed	Hunts	W95/BD12
C511	0.005μF		Fixed	Hunts	W95/BD12
C512	0.005μF		Fixed	Hunts	W95/BD12
C513	0.005μF		Fixed	Hunts	W95/BD12
C514	0.005μF		Fixed	Hunts	W95/BD12
C515	0.005μF		Fixed	Hunts	W95/BD12
C516	0.005μF		Fixed	Hunts	W95/BD12
C517	0.005μF		Fixed	Hunts	W95/BD12
C518	500pF	10%, 125V	Fixed, polystyrene	G.E.C.	PF
C601	47μF	16V	Fixed, electrolytic	Printilyt	
C602	220μF	35V	Fixed, electrolytic	Printilyt	
C603	47μF	16V	Fixed, electrolytic	Printilyt	
C604	0.02μF		Fixed	Hunts	W95/BD14
C605	0.02μF		Fixed	Hunts	W95/BD14
C606	0.15μF	1.1%, 125V	Fixed	T.M.C.	S126008
C607	0.02μF		Fixed	Hunts	W95/BD14
C608	0.02μF		Fixed	Hunts	W95/BD14
C609	0.15μF	1.1%, 125V	Fixed	T.M.C.	S126008
C610	0.05μF		Fixed	T.M.C.	S125667
C611	0.05μF		Fixed	T.M.C.	S125667
C701	0.001μF	20%	Disc	Erie	K350081/831
C702	15pF	0.25%	Fixed	Erie	NPO/AD Epitex
C703	6.2pF	0.1pF	Fixed	Erie	P100/AD Epitex
C704	Not used				
C705	0.001μF	20%	Disc	Erie	K350081/831
C706	0.002μF	20%	Disc	Erie	K7004/831
C707	0.001μF	20%	Disc	Erie	K350081/831
C708	0.001μF	20%	Disc	Erie	K350081/831
C709	2.2pF	5%	Fixed	Erie	N750/AD Epitex
C710	5.1pF	5%	Fixed	Erie	N750/AD Epitex

Reference	Value	Tolerance or rating	Description	Manufacturers	
				Name	Type
C711	0.001μF	20%	Disc	Erie	K350081/831
C712	47pF	5%	Fixed	Erie	N750/AD Epitex
C713	0.001μF	20%	Disc	Erie	K35008/831
C714	0.001μF	20%	Disc	Erie	K35008/831
C715	2.7pF	0.25pF	Fixed, ceramic	Erie	N750 Epitex AD
C716	Not used				
C717	1.8pF	5%	Fixed	Erie	N750/AD Epitex
C718	0.001μF		Feed Through	Erie	K7004/CDFT100
C719	0.001μF	20%	Disc	Erie	K350081/831
C720	2.7pF	0.25pF	Fixed, ceramic	Erie	N750 Epitex AD
C721	0.001μF	20%	Disc	Erie	K350081/831
C722	Not used				
C723	47pF	5%	Fixed	Erie	N750/AD Epitex
C724	18pF	5%	Fixed	Erie	N750/AD Epitex
C725	0.002μF	25%	Disc	Erie	K7004/831
C726	5.6pF	5%	Fixed	Erie	N750/AD Epitex
C727	0.002μF	25%	Disc	Erie	K7004/831
C728	0.002μF	25%	Disc	Erie	K7004/831
C729	0.002μF	25%	Disc	Erie	K7004/831
C730	18pF	5%	Fixed	Erie	N750/AD Epitex
C731	5.6pF	5%	Fixed	Erie	N750/AD Epitex
C732	0.002μF	25%	Disc	Erie	K7004/831
C733	0.002μF	25%	Disc	Erie	K7004/831
C734	18pF	5%	Fixed	Erie	N750/AD Epitex
C735	0.001μF	20%	Fixed, ceramic	Erie	K350081/831
C736	6.2pF	5%	Fixed	Erie	N750/AD Epitex
C737	6.8pF	5%	Fixed	Erie	N750/AD Epitex
C738	22μF	35V	Fixed, electrolytic	Printilyt	
C739	0.002μF	25%	Disc	Erie	K7004/831
C740	0.002μF	25%	Disc	Erie	K7004/831
C741	0.047μF	12V	Ceramic disc		LV
C742	0.002μF	25%	Disc	Erie	K7004/831
C743	220μF	35V	Fixed, electrolytic	Printilyt	
C744	220μF	35V	Fixed, electrolytic	Printilyt	
C745	500μF	12V	Fixed, electrolytic	Hunts	MEF25AT
C746	220μF	35V	Fixed, electrolytic	Printilyt	
C747	1000pF	20%	Fixed	Erie	K350081/831
C748	1.5 to 10pF		Variable	Wingrove & Rogers	S5801/10
C749	1000pF		Feed through	Erie	K7004/CDFT100
C750	1000pF	20%	Fixed	Erie	K350081/831
C751	1000pF		Feed through	Erie	K7004/CDFT100
C752	1000pF		Feed through	Erie	K7004/CDFT100
C753	1000pF	20%	Fixed	Erie	K350081/831
C754	27pF	5%	Fixed	Erie	N750/AD Epitex
C755	1000pF		Feed through	Erie	K7004/CDFT100
C756	3.9pF	5%	Fixed	Erie	N470/AD Epitex
C757	Not used				
C758	1000pF		Feed through	Erie	K7004/CDFT100
C759	1pF		Fixed	Erie	N470/AD Epitex
C760	1000pF		Feed through	Erie	K7004/CDFT100
C761	5 to 6pF		Variable	Erie	CT49-101/N080
C762	1000pF		Feed through	Erie	K7004/CDFT100
C763	1.5pF	5%	Fixed	Erie	N220/AD Epitex
C764	1000pF		Feed through	Erie	K7004/CDFT100
C765	1000pF		Feed through	Erie	K7004/CDFT100
C766	Not used				
C767	Not used				
C768	0.01μF	20%, 125V	Fixed	Wima	Tropyfol F
C769	Selected		Fixed, A.I.C.	Erie	N750/AD Epitex
C770	0.002μF	25%	Disc	Erie	K7004/831
C771	Selected		Fixed, A.I.C.	Erie	N750/AD Epitex
C772	1pF		Fixed	Erie	N470/AD Epitex
C773	50pF	5%	Fixed	Erie	N750/A
C801	1000μF	25V	Fixed, electrolytic	Hunts	KB57T
C802	1000μF	25V	Fixed, electrolytic	Hunts	KB57T
C803	500μF		Fixed	Hunts	MEF25AT
C804	500μF		Fixed	Hunts	MEF25AT
C805	500μF		Fixed	Hunts	MEF25AT
C806	500μF		Fixed	Hunts	MEF25AT
C900	0.03μF	2%, 150V	Fixed, Polyester	Salford	PFT

Reference	Value	Tolerance or rating	Description	Manufacturers	
				Name	Type
C901	0.5μF	2%, 160V	Fixed, Polyester	Salford	PFT
C1001	0.5μF	2%	Fixed	G.E.C.	A596
C1002	0.1μF	2%	Fixed	G.E.C.	PF polystyrene
C1003	Not used				
C1004	2.2μF	20%, 63V	Fixed	Wima	MKS
C1005	68μF	16V	Fixed	Mullard	016-15689
C1006	470μF	16V	Fixed	Printilyt	
C1007	3.0pF	5%	Ceramic disc	Erie	831

Transistors

Reference	Manufacturers	
	Name	Type
VT101	Mullard	BCZ11
VT102	Mullard	ACY17
VT103	Mullard	OC44
VT104	Mullard	ACY17
VT105	Texas	2N1304
VT106	Mullard	ACY17
VT107	Mullard	ACY17
VT108	Mullard	ACY17
VT109	Mullard	OC42
VT110	Mullard	OC42
VT111	Texas	2N929
VT201	Mullard	OC44
VT202	Mullard	OC202
VT203	Mullard	OC44
VT204	Mullard	OC202
VT205	Mullard	OC202
VT206	Mullard	ACY17
VT207	Mullard	ACY17
VT208	Texas	2N1304
VT209	Mullard	OC42
VT210	Texas	2N1304
VT211	Mullard	OC42
VT301	Mullard	OC44
VT302	Mullard	OC44
VT303	Mullard	OC44
VT304	Mullard	ACY17
VT305	Texas	2N1304
VT306	Mullard	OC44
VT307	Mullard	OC44
VT308	Mullard	OC202
VT309	Mullard	OC44
VT310	Mullard	ACY17
VT311	Mullard	ACY17
VT312	Texas	2N1304
VT313	Mullard	OC42
VT314	Mullard	ACY17
VT315	Mullard	BC108
VT401	Texas	2N1304
VT402	Mullard	BCZ11
VT403	Texas	2S702
VT404	Texas	2S702
VT405	Mullard	BCZ11
VT406	Texas	2N1304
VT407	Mullard	BC108
VT408	Mullard	BCZ11
VT409	Texas	2N1304
VT410	Mullard	OC42
VT411	Mullard	ACY17
VT412	Texas	2N1304
VT413	Texas	2N1304
VT414	Mullard	OC42
VT415	Mullard	ACY17
VT416	Mullard	OC42
VT417	Mullard	OC42
VT501	Texas	2N1304

Reference	Manufacturers	
	Name	Type
VT502	Texas	2N1304
VT503	Texas	2N1304
VT504	Texas	2N1304
VT505A	Mullard	BCY70
VT505B	Mullard	BC107
VT506	S.T.C.	BSY27
VT507	S.T.C.	BSY27
VT508	Texas	2N1304
VT509	Texas	2N1304
VT510	Texas	2N1304
VT511	Texas	2N1304
VT512	Texas	2N1304
VT513	Texas	2N1304
VT601	Mullard	OC44
VT602	Texas	2N1304
VT603	Mullard	OC44
VT604	Mullard	OC44
VT605	Mullard	OC42
VT606	Mullard	OC42
VT607	Mullard	OC42
VT608	Texas	2N1304
VT609	Mullard	BCY70
VT610	Mullard	BCY70
VT611	Texas	2N1304
VT612	Mullard	BC108
VT701	Mullard	AFZ12
VT702	Mullard	AFZ11
VT703	Mullard	AFZ11
VT704	Mullard	AFZ11
VY705	Mullard	AFZ11
VT706A	Mullard	BC107
VT706B	Motorola	MPS918
VT707	Mullard	OC202
VT708	Texas	2N1304
VT709	Mullard	OC44
VT710	Mullard	BCY70
VT711	Texas	GM0290
VT712	Mullard	AFZ12
VT713	Mullard	AFZ12
VT801	Mullard	OC36
VT802	Texas	2N1304
VT803	Texas	2N1304
VT804	Mullard	ACY17
VT805	Mullard	ACY17
VT806	Mullard	OC36
VT900	Texas	2N929
VT901	Mullard	BCZ11
VT1001	Mullard	2N930
VT1002	Mullard	BCY34
VT1003	Mullard	BC109
VT1004	Mullard	BCY31
VT1005	Mullard	BC109
VT1006	Mullard	BCY31
VT1007	Mullard	BCY72
VT1008	Mullard	BC109

Diodes

Reference	Manufacturers	
	Name	Type
MR1	Mullard	OA81
MR2	Mullard	OA81
MR3	Mullard	OA81
MR4	Mullard	OA81
MR5	Mullard	OA81
MR6	Mullard	OA81
MR101	Mullard	BZY88C4V7
MR102	Mullard	OA200
MR103	Mullard	OA200
MR301	Mullard	OA81
MR302	Mullard	OA81
MR303	Texas	IN4148
MR304	Texas	IN4148
MR401	Mullard	OA200
MR402	Mullard	OA200
MR403	Mullard	OAZ244
MR404	Mullard	OAZ244
MR405	Mullard	OA200
MR406	Mullard	OA200
MR407	Mullard	OA81
MR408	Mullard	OA81
MR409	Mullard	OA200
MR410	Mullard	OA81
MR411	Mullard	OA81
MR412	Mullard	OA81
MR501	Mullard	OA91
MR502	Mullard	OA91
MR503	Mullard	OA91
MR504	Mullard	OA91
MR505	Mullard	OA91
MR506	Mullard	OA91
MR507	Mullard	BZY88
MR510	Mullard	OA91
MR511	Mullard	OA91
MR512	Mullard	OA91
MR513	Mullard	OA91
MR514	Mullard	OA91

Reference	Manufacturers	
	Name	Type
MR515	Mullard	OA91
MR516	Mullard	OA91
MR517	Mullard	OA91
MR518	Mullard	OA91
MR519	Mullard	OA91
MR520	Texas	1S921
MR601	Mullard	OAZ244
MR602	Mullard	OA81
MR603	Mullard	OA81
MR604	Mullard	OA81
MR605	Mullard	OAZ244
MR606	Mullard	OA81
MR607	Mullard	OA200
MR608	Mullard	OA200
MR609	Mullard	OA200
MR610	Mullard	OA200
MR701	Mullard	OA90
MR702	Mullard	AAZ15
MR703	Mullard	AAZ15
MR704	Mullard	AAZ15
MR705	Texas	1N914
MR706	Hughes	HD5000
MR707	Mullard	OAZ243
MR708	Mullard	OAZ243
MR709	Mullard	OA200
MR710	Mullard	OA200
MR711	Not used	
MR712	Ferranti	ZC700
MR713	Not used	
MR714	Mullard	OAZ245
MR715	Texas	1N914
MR801	Texas	1B05JO5 (Bridge rectifier)
MR802	Mullard	OA200
MR803	Mullard	OAZ244
MR804	Mullard	OAZ244
MR805	Mullard	OA200

Transformers

Reference	Manufacturers		Wayne Kerr Dwg. No.
	Name	Type	
T101	Belclere	LX Mumetal	D12693
T201	Belclere	LX Mumetal	D12633
T301	Belclere	GX Radiometal	D12636
T302	Belclere	EN Radiometal	D12635
T401	Belclere	LX Mumetal	D12634
T402	Belclere	LX Mumetal	D12634

Reference	Manufacturers		Wayne Kerr Dwg. No.
	Name	Type	
T701	Wayne Kerr		D12682
T702	Wayne Kerr		D12683
T703	Wayne Kerr		D12683
T704	Wayne Kerr		D12689
T705	Wayne Kerr		D12870
T801	Wayne Kerr	MT/A 1002	
T1001		Toroid	D1656

Inductors

Reference	Description	Manufacturers	
		Name	Type
L701		Wayne Kerr	Dwg. D12695
L702	R.F. choke 2.95μH	Painton	58/10/2002/25
L703		Wayne Kerr	Dwg. D12685
L704		Wayne Kerr	Dwg. D12686
L705		Wayne Kerr	Dwg. D12867
L706	Not used		
L707	R.F. choke 2.95μH	Painton	58/10/2002/25
L708	R.F. choke 17.5μH	Painton	200150
L709	R.F. choke 2.95μH	Painton	58/10/2002/25
L710	Not used		
L711		Wayne Kerr	Dwg. D12882
L712	R.F. choke 2.95μH	Painton	200151

Reference	Description	Manufacturers	
		Name	Type
L713 L714	17.5μH	Wayne Kerr Painton	Dwg. D12881 200150

Integrated Circuits

IC301	National Semiconductor	LM301A
IC302	National Semiconductor	LM301A
IC303	National Semiconductor	LM301A

Miscellaneous

Reference	Description	Manufacturers	
		Name	Type
Switches			
S1	4-pole, on/off	Arrow	93A/417-B-13
S2	Wayne Kerr Dwg. D12	A.B. Metal	212
S3	D.P.D.T. biased off	Arrow	81358-133
S4	Wayne Kerr Dwg. D12	A.B. Metal	
S5	Wayne Kerr Dwg. D12855		
S6	D.P.D.T.	Arrow	81058/BT/13
S7	S.P. on/off, biased off	Arrow	81346E
EXT/INT	D.P.D.T.	Arcolectric	T225
Jacks			
JK1		Igranic	P73
JK2		Igranic	P73
JK3		Igranic	P73
Fuses			
F801	(Fuse link 1A	Belling & Lee	L562
	(Fuse holder size 00	Belling & Lee	L575
F802	(Fuse link 1A	Belling & Lee	L562
	(Fuse holder size 00	Belling & Lee	L575
F803	(Fuse link 250 mA	Belling & Lee	L562
	(Fuse holder size 00	Belling & Lee	L575
F804	(Fuse link 250 mA	Belling & Lee	L562
	(Fuse holder size 00	Belling & Lee	L575
Lamp			
LP1	Lampholder	Bulgin	D805/Red
	Bulb, 14V, 0.75W, 5mm	Vitality	LES
	Cap adaptor	Bulgin	9195
Test points			
TP3 to TP9	Socket, black, 4mm	Belling & Lee	L1318
SKT5, SKT7	Socket, black, 4mm	Belling & Lee	L1318
SKT4, SKT6	Socket, red, 4mm	Belling & Lee	L1318
All others		A.E.I.	WS1
Meters			
M1	0–250μA	M.I.P.	P20
M2	100–0–100μA	M.I.P.	P30
M3	50–0–50μA	M.I.P.	P20
Voltage selector			
–		McMurdo	BVS/4

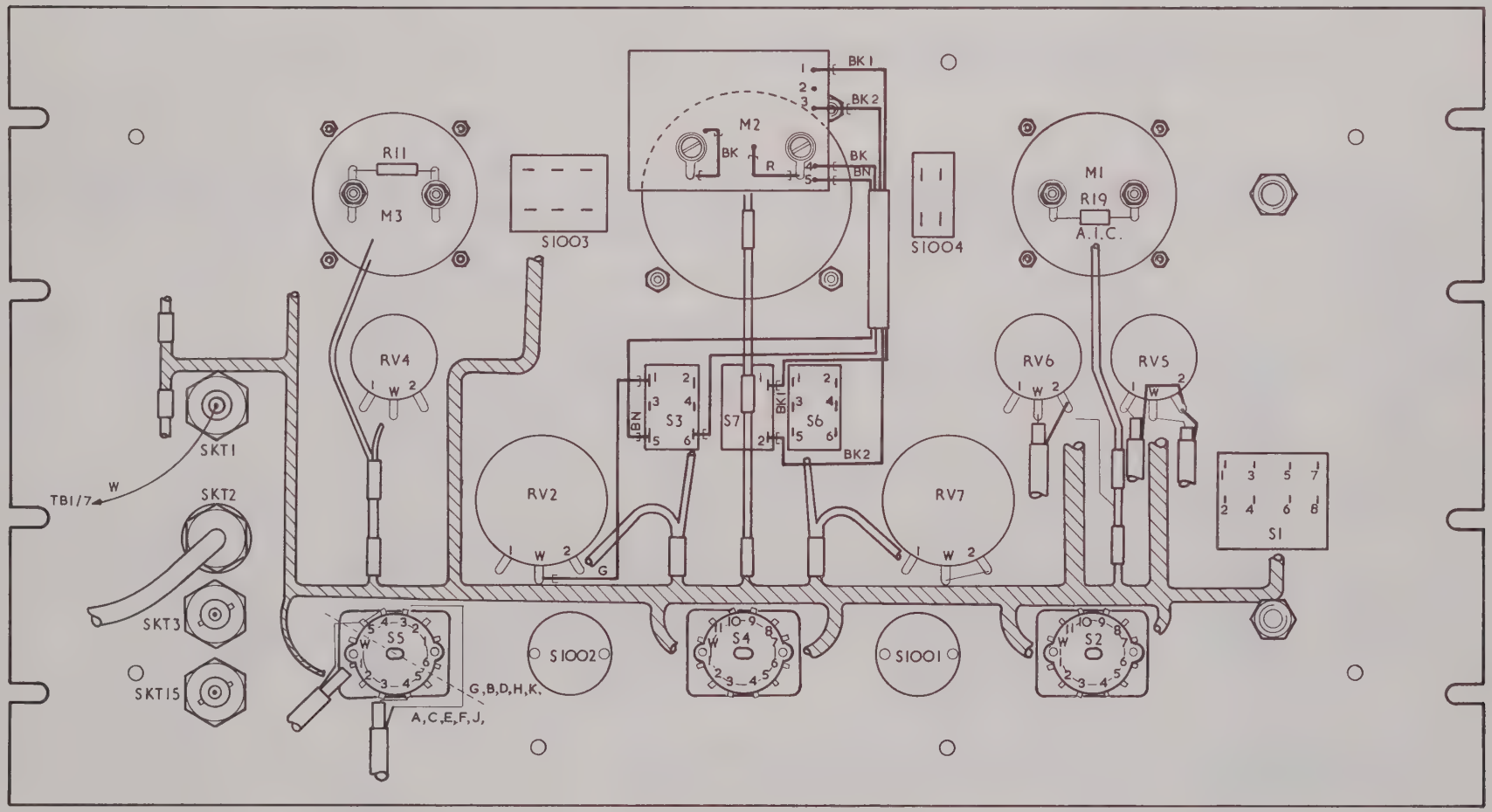


FIG.30 FRONT PANEL ASSEMBLY
D12852/L

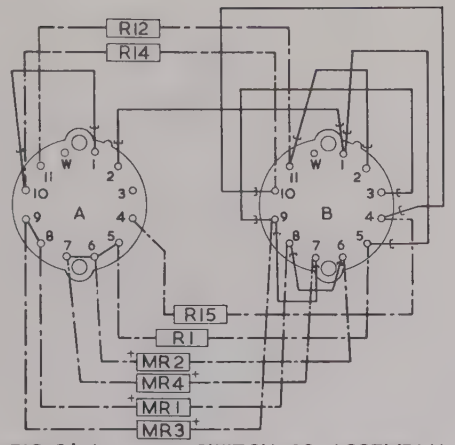
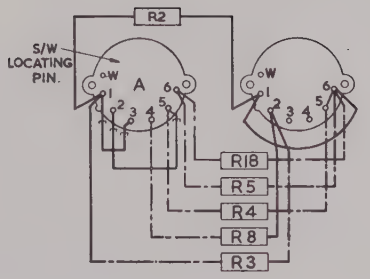


FIG. 31 A. SWITCH S2 ASSEMBLY
D12728/D (VIEWED FROM THE FRONT)



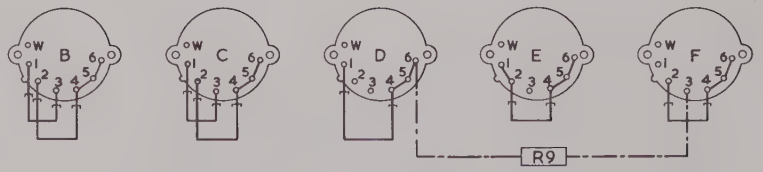


FIG. 31B SWITCH S4 ASSEMBLY (VIEWED FROM THE REAR)
D12727/D

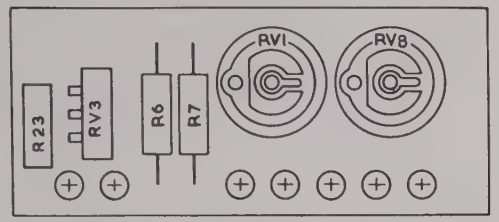


FIG.32 A POTENTIOMETER
TAGBOARD P.C.B. D12857/C

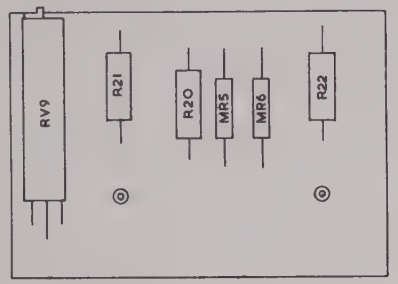
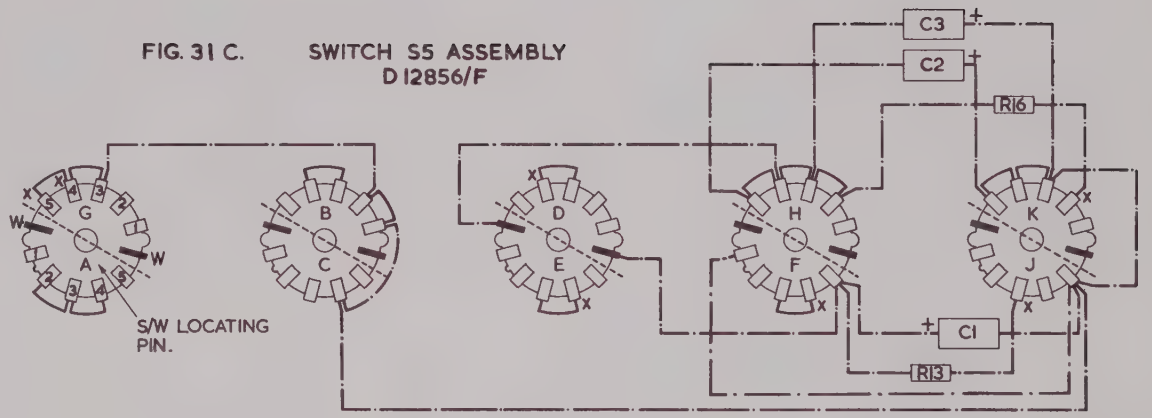


Fig 32B METER TAGBOARD P.C.B.
D12889/B

FIG. 31 C. SWITCH S5 ASSEMBLY
D12856/F



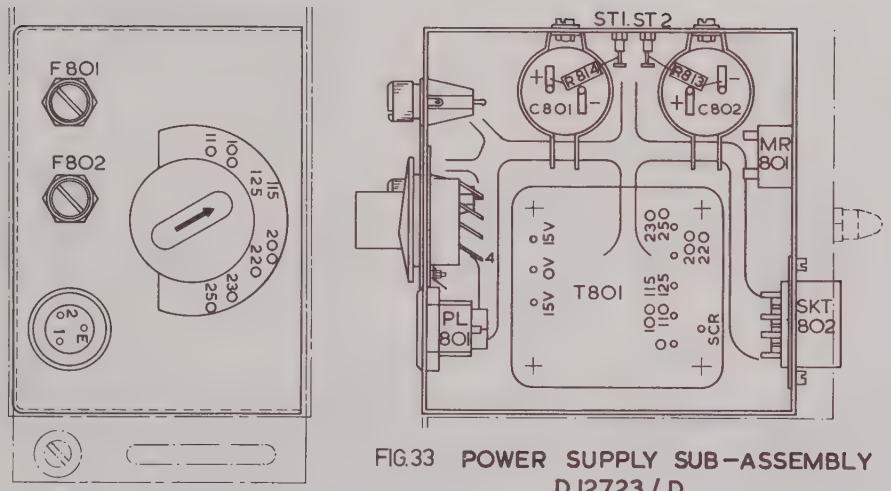


FIG.33 POWER SUPPLY SUB-ASSEMBLY
D 12723 / D

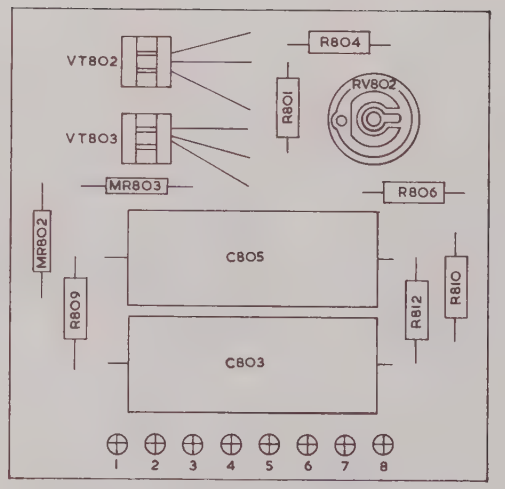


FIG.34A +11V STABILISER P.C.B.
D12733/C

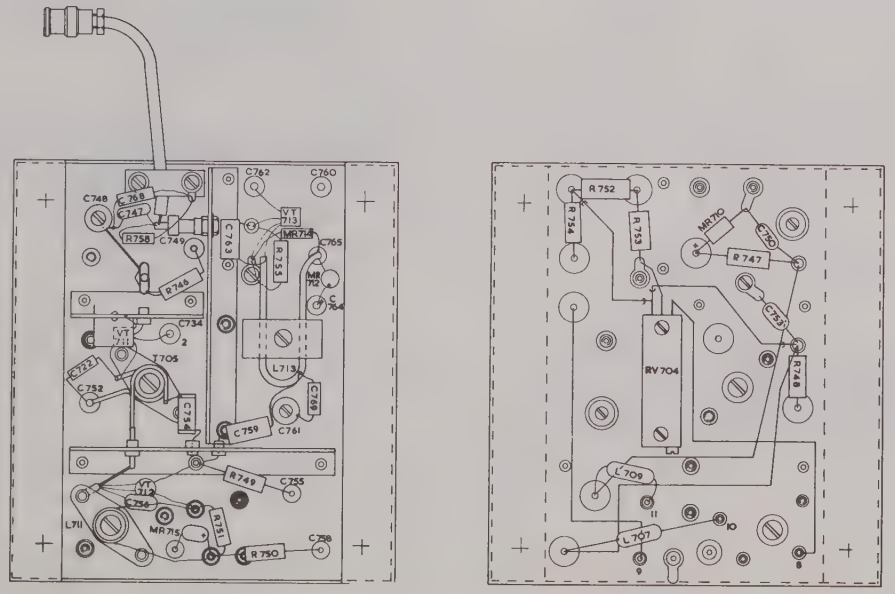


FIG. 35 A RECEIVER GLIDE PATH ASSEMBLY

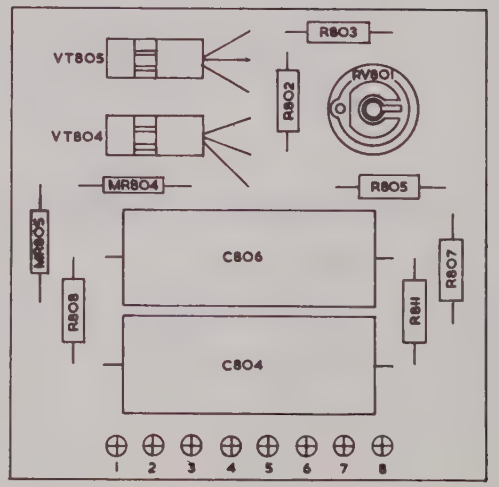


FIG.34B -11V STABILISER P.C.B.
D12714/C

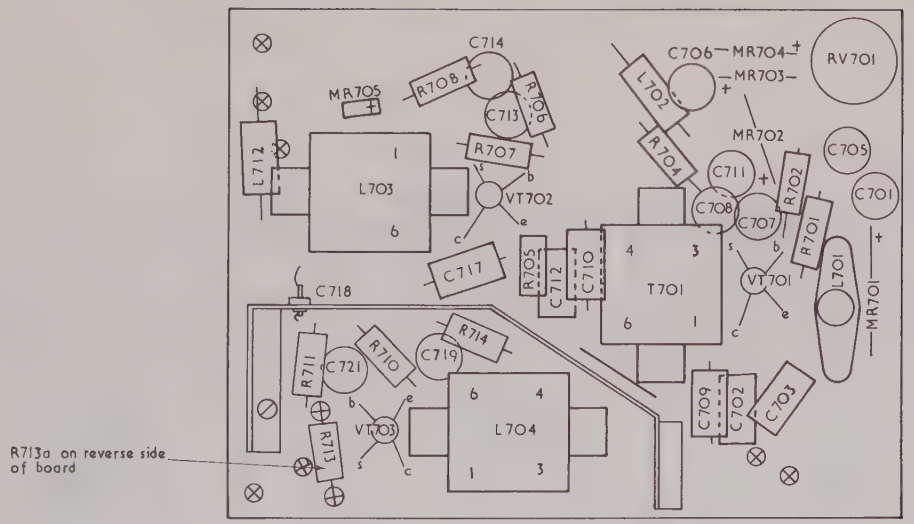


FIG. 35b RECEIVER LOCALISER P.C.B
D12867/H

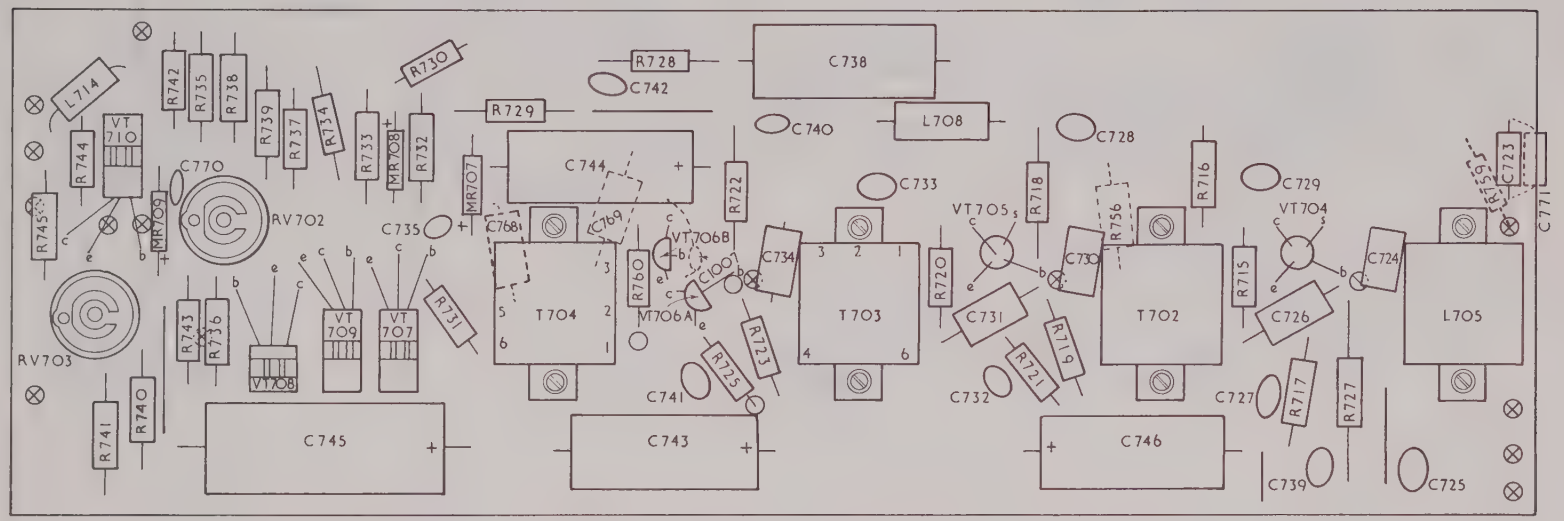


FIG. 35c RECEIVER I.F. STRIP P.C.B.
D12864/P

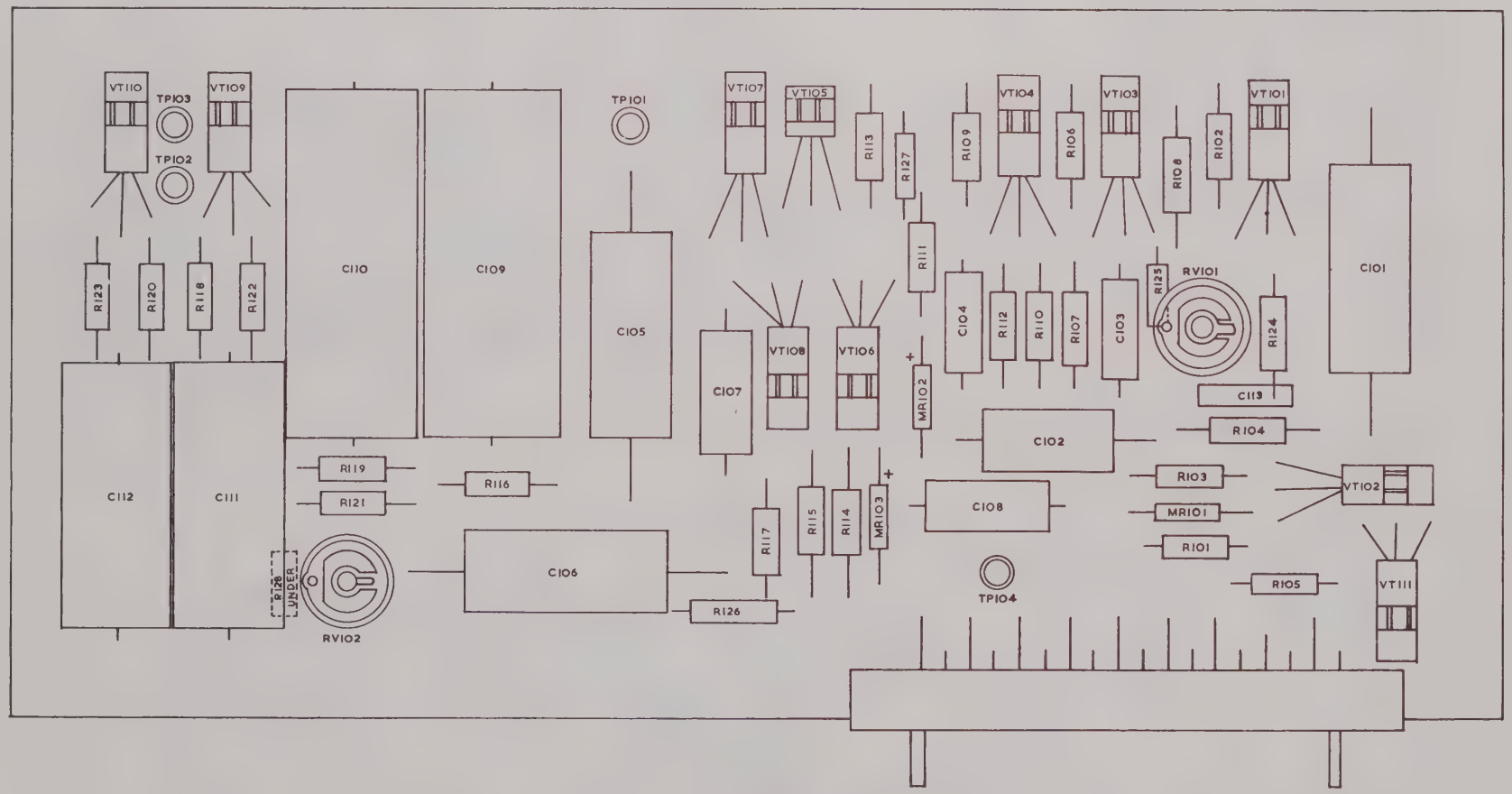


FIG.36. UNIT 1 P.C.B. BUFFER AMP. & MULTIPLIER
D12696/J

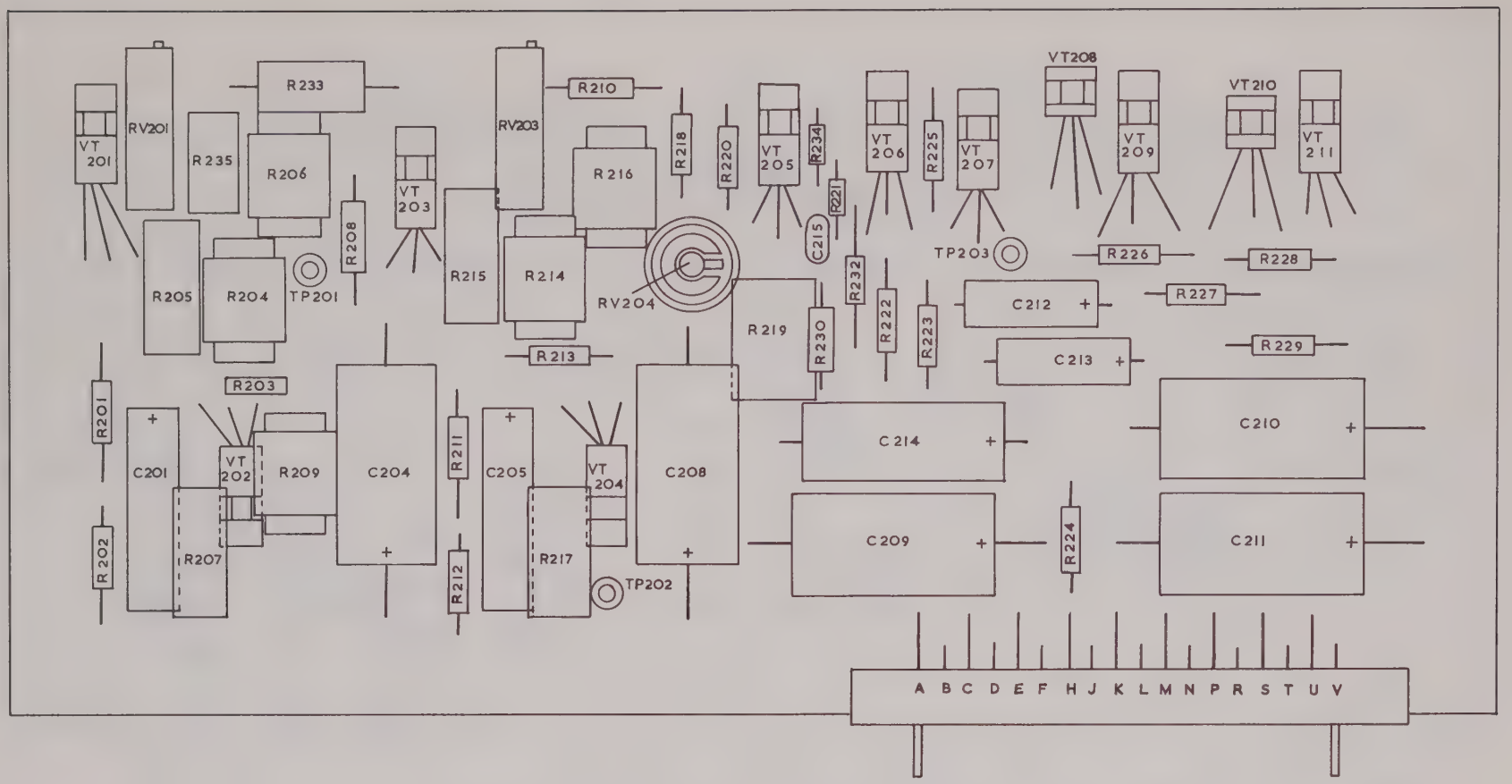


FIG. 37 UNIT 2 P.C.B. 30 c/s AMP. & P.S.D
D12697/K

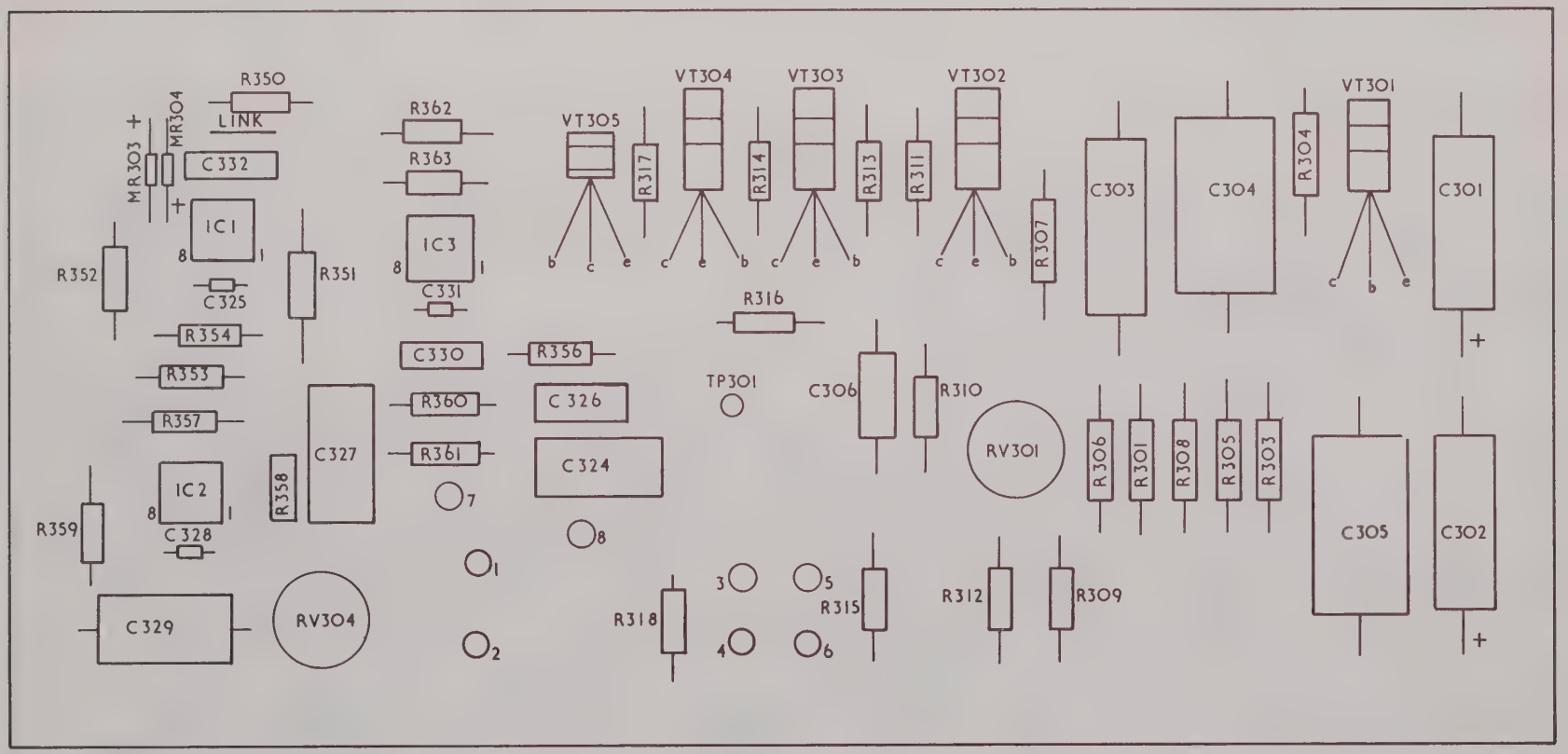


FIG. 38A UNIT 3 90c/s FILTER P.C.B.
D12699/E

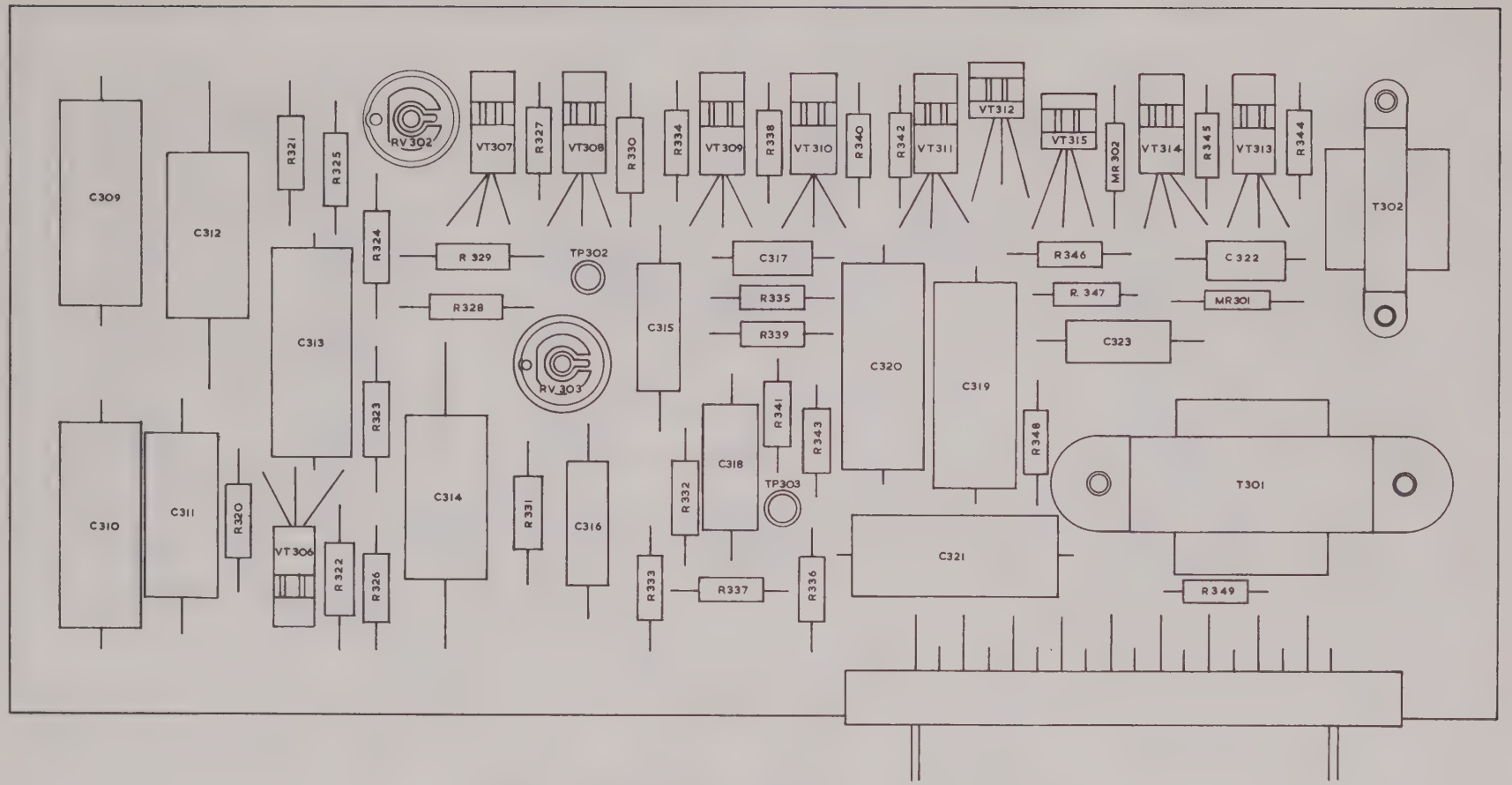


FIG.38B UNIT 3 150 c/s FILTER AND SQUARER P. C. B.
D12698/C

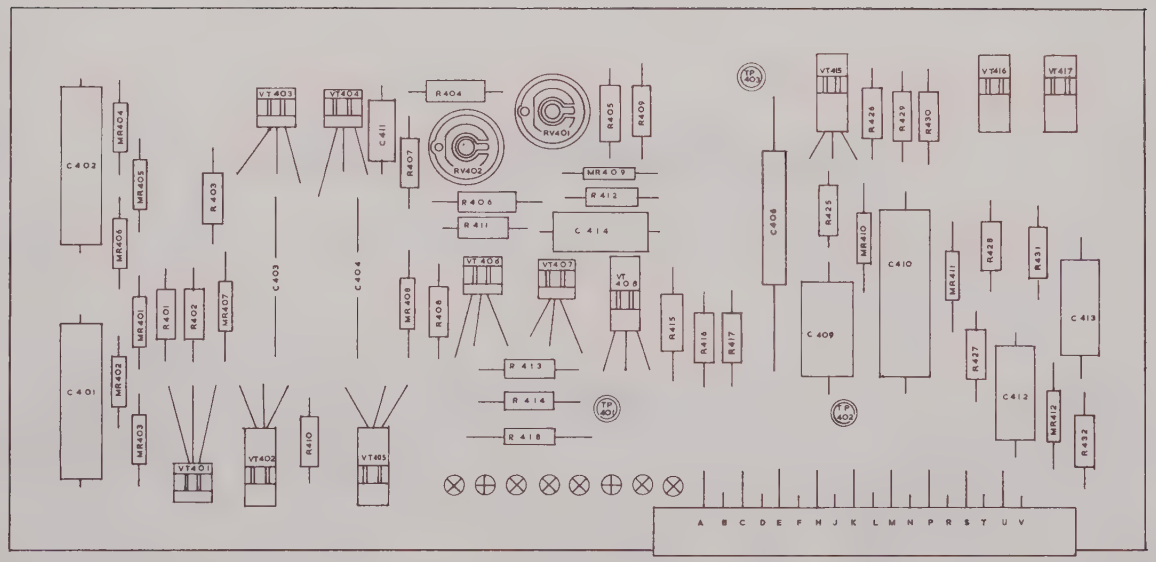


FIG. 39A UNIT 4 REFERENCE GENERATOR P.C.B.
D12700/H

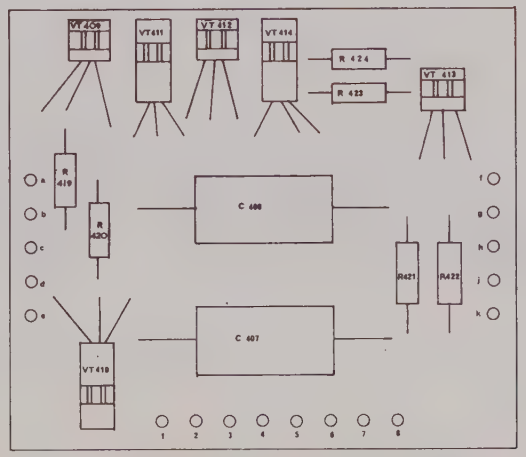


FIG. 39B UNIT 4 REFERENCE DETECTORS P.C.B.
D12709/D

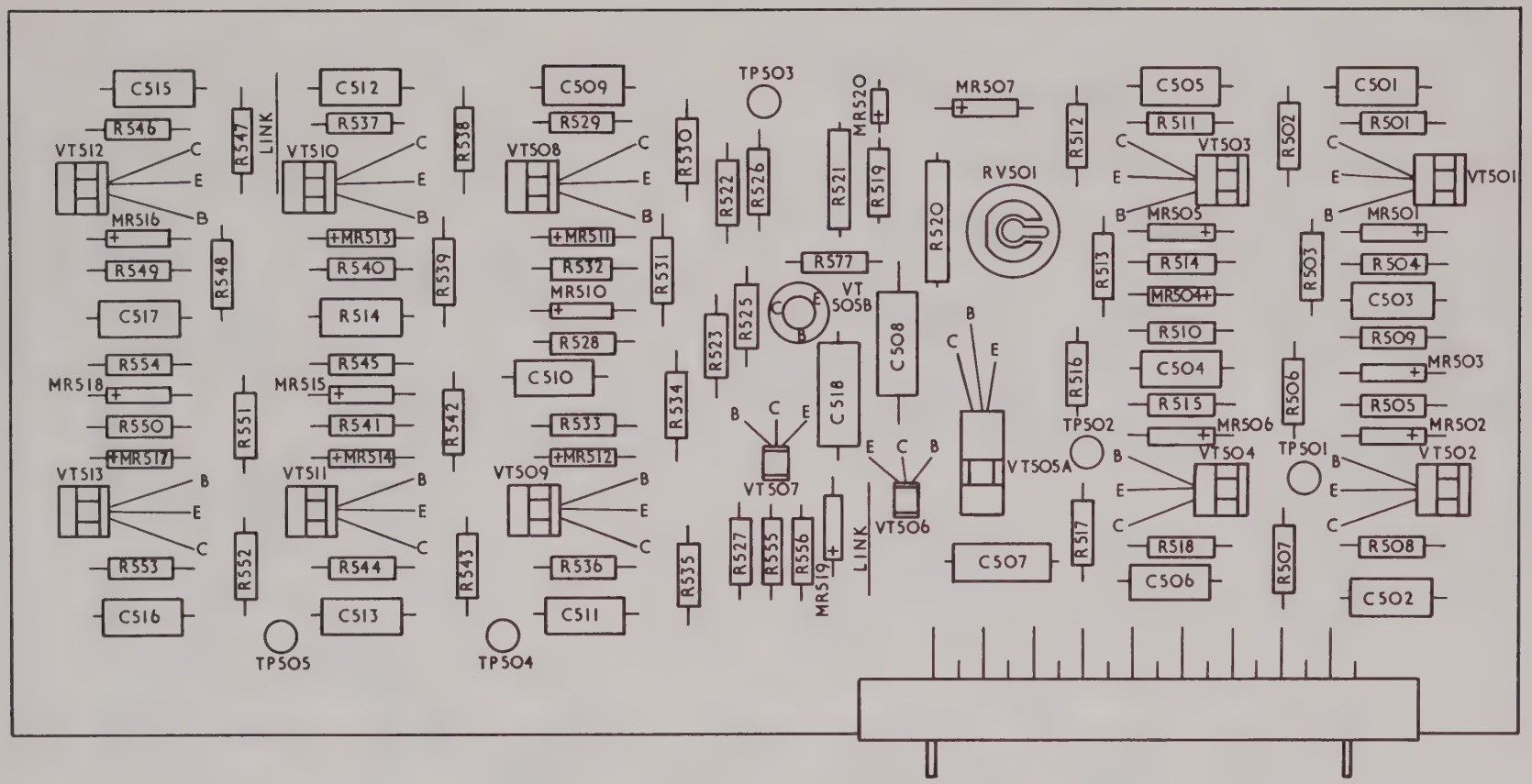


FIG.40 UNIT 5 P.C.B. BINARY UNIT
DI2710/J

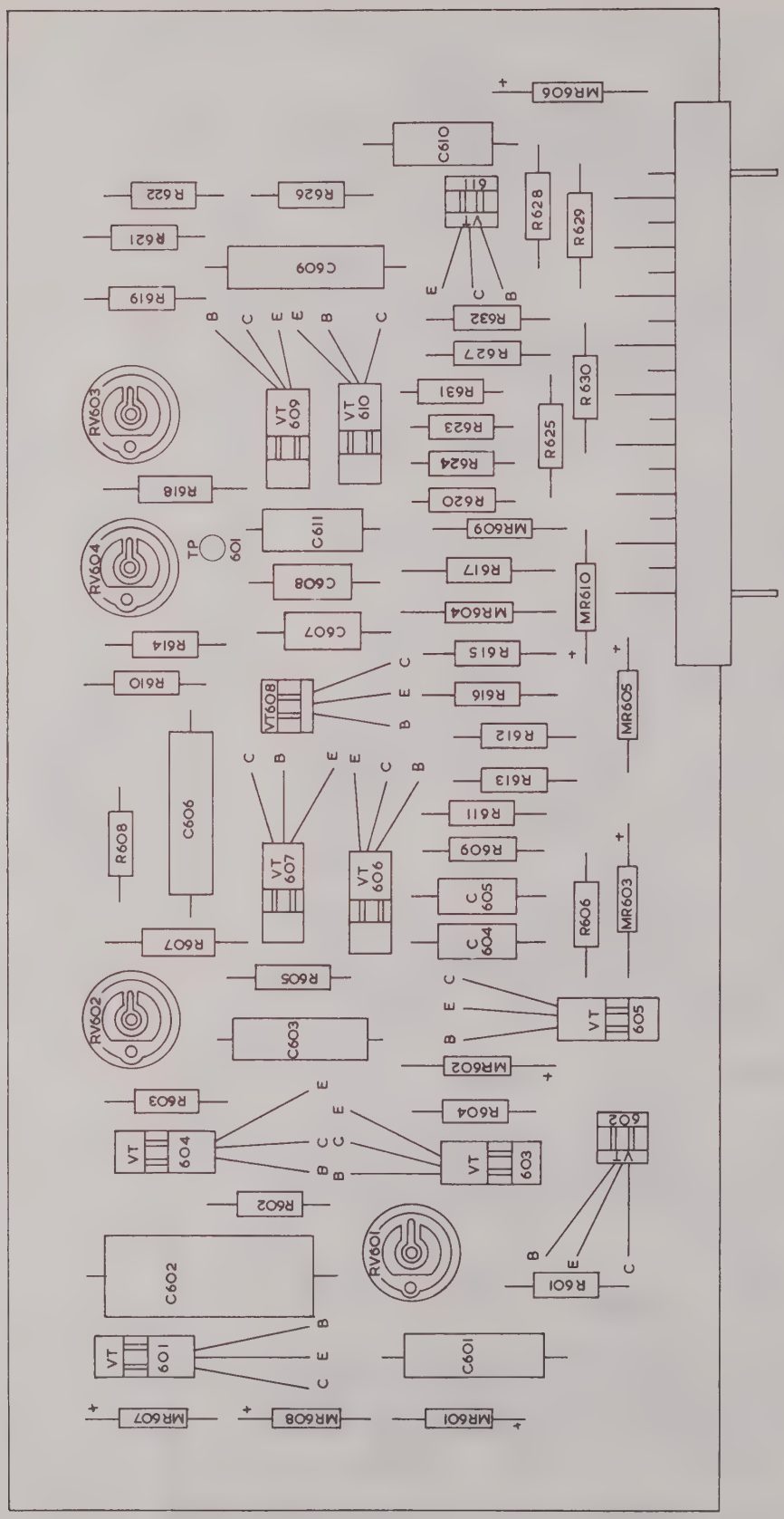


FIG.41. UNIT 6 P.C.B. SYNC. PULSE GEN. D12711/J

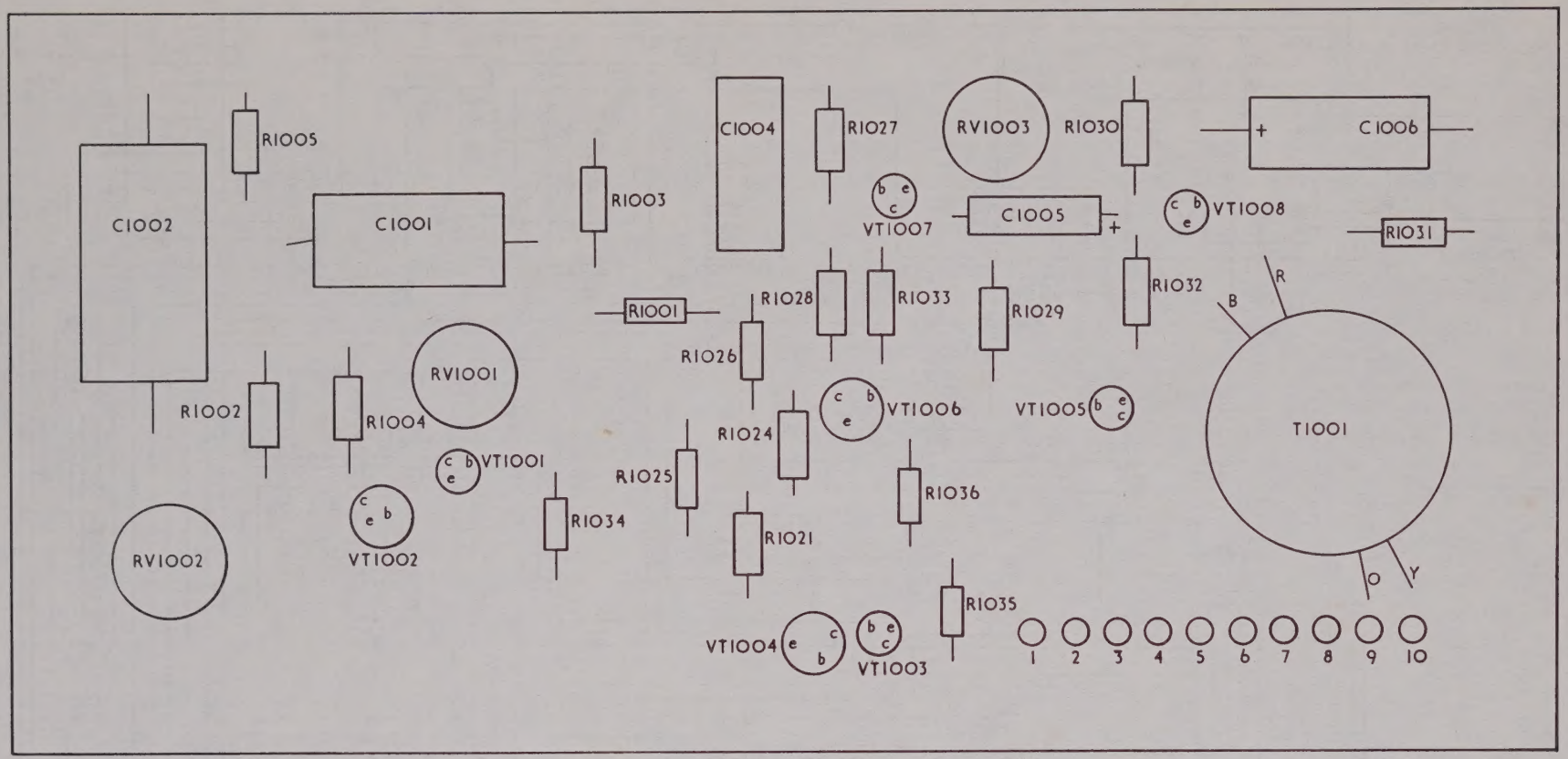


FIG. 42 OFFSET D.D.M. P.C.B. D16129

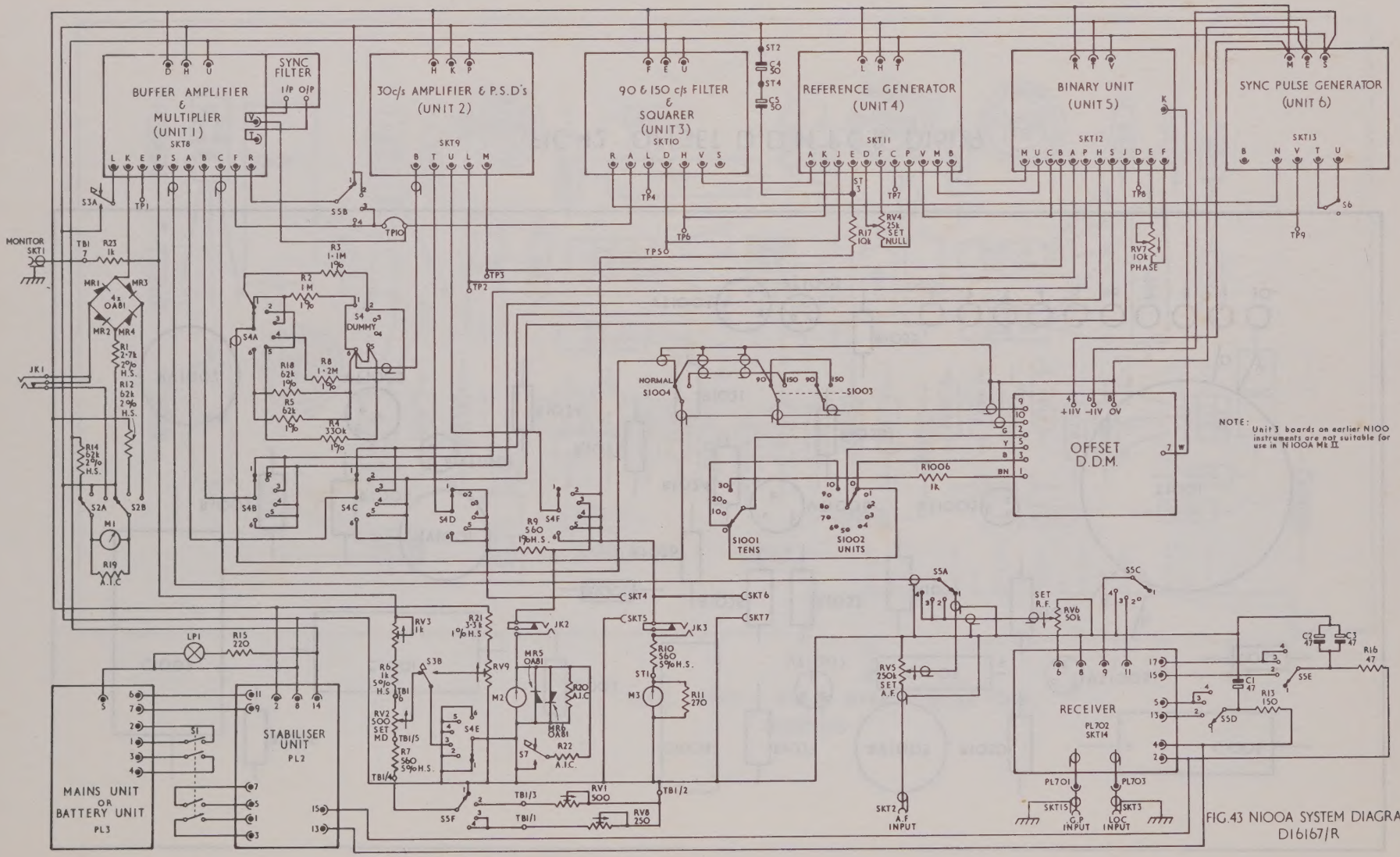

BUFFER AMPLIFIER & MULTIPLIER (UNIT 1)
SYNC FILTER
30c/s AMPLIFIER & P.S.D's (UNIT 2)
90 & 150 c/s FILTER & SQUARER (UNIT 3)
REFERENCE GENERATOR (UNIT 4)
BINARY UNIT (UNIT 5)
SYNC PULSE GENERATOR (UNIT 6)
OFFSET D.D.M.
S1001 TENS
S1002 UNITS
RECEIVER PL702 SKT14
STABILISER UNIT PL2
MAINS UNIT OR BATTERY UNIT PL3
NOTE: Unit 3 boards on earlier N100 instruments are not suitable for use in N100A Mk II

FIG.43 N100A SYSTEM DIAGRAM D16167/R

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Printed in England L&L/2.75/200